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NOVEMBER 1999

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12v 18Ah SEALED LEAD ACID BATTERIES, new and boxed, unused pack of 4 £39.95 ref CYC7 or £15 each ref CYC6

AUTOMATIC CHARGER For the above batteries, charges 2 at once, charge level indicator circuitry, 6 hour charge. £10 ref CYC8

A new range of 12v to 240v INVERTERS

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IV800S (800 watt) £159

IV1200S (1200 watt) £219

ECG MACHINES?/6v 10AH BATTS/24V 8A TX Ex government ECG machines! Measures 390X320X120mm, on the front are controls for scan speed, scan delay, scan mode, loads of connections on the rear including video out etc. On the front panel are two DIN sockets for connecting the body sensors to. Sensors not included, Inside 2 x 6v 10AH sealed lead acid batts (generally not in good condition), pcb's and a 8A? 24v torroidial transformer (mains in). sold as seen, may have one or two broken knobs etc due to poor storage. £15.99 ref VP2

SODIUM LAMP SYSTEMS £75.70 Complete system with 250w or 400 watt SON-T Agro bulb, reflector with bulb holder and remote ballast and starter(uncased) all you need is wire. 250W system ref SLS1, 400W system SLS2.

PC SUPPORT HANDBOOK The ultimate technical guide to building and maintaining PC's. Over 460 A4 pages packed with technical data and diagrams just £10 ref PCBK. If you want 4 copies for £33 ref PCBK2. Also available is a CD packed with diagnostic programmes to use with the book £5 ref PCBK1

D SIZE NICADS Tagged, 1200mA, 1.2v pack of 4 for £6 ref CYC9 or as a pack of 24 for £22 ref CYC10

D SIZE SEALED LEAD ACID BATTERIES

2v 2.5ah rechargeable sealed lead acid battery made by Cyclon. 60x45mm (standard D size) supplied as a pack of 12 or 20 giving you options for battery configerations eg 12v at 5ah, 24v at 2.5ah, 6v at 10ah. These batteries are particularly useful in that you can arrange them in your project to optimise space etc (eg boat ballast etc) Pack of 12 £10 ref CYC4, pack of 20 £16 ref CYC5

HYDROPONICS DO YOU GROW YOUR OWN?

We have a full colour hydroponics catalogue available containing nutrients, pumps, fittings, enviromental control, light fittings, plants, test equipment etc Ring for your **free copy.**

PC COMBINED UPS AND PSU The unit has a total power of 292 watts, standard mother board connectors and 12 peripheral power leads for drives etc. Inside is 3 12v 7.2aH sealed lead acid batteries. Backup time is 8 mins at full load or 30 mins at half load. Made in the UK by Magnum, 110 or 240vac input, +5v at 35A, -5v at .5A, +12v at 9A, -12v at .5A outputs. 170x260x220mm, new and boxed. £29.95 Ref PCUPS2

ALTERNATIVE ENERGY CD, PACKED WITH HUNDREDS OF ALTERNATIVE ENERGY RELATED ARTICLES,PLANS AND INFORMATION ETC £14.50 REF CD56

AERIAL PHOTOGRAPHY KIT This rocket comes with a built in camera! it flies up to 500 feet (150 m) turns over, and takes an aerial photograph of the ground below. The rocket then returns wih its film via its paracute. Takes 110 film. Supplied complete with everything including a launch pad and 3 motors (no film) £29.98 ref astro

PROJECT BOXES Another bargain for you are these smart ABS project boxes, smart two piece screw together case measuring approx 6"x5"x2" complete with panel mounted LED. Inside you will find loads of free bits, tape heads, motors, chips resistors, transistors etc. Pack of 20 £19.95 ref MD2

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3HP MAINS MOTORS Single phase 240v, brand new, 2 pole, 340x180mm, 2850 rpm, builtin automatice reset overload protector, keyed shaft (40x16mm)Made by Leeson. £99 each ref LEE1

BUILD YOU OWN WINDFARM FROM SCRAP

New publication gives step by step guide to building wind generators and propellors. Armed with this publication and a good local scrap yard could make you self sufficient in electricity! £12 ref LOT81

CHIEFTAN TANK DOUBLE LASERS 9 WATT+3 WATT+LASER OPTICS Could be adapted for laser listener, long range comms etc Double beam units designed to fit in the barrel of a tank, each unit has 2 semi conductor lasers and motor drive units for alignement. 7 mile range, no circuit diagrams due to MOD, new price £50,000? us? £199. Each unit has two gallium Arsenide injection lasers, 1 x 9 watt, 1 x 3 watt, 900nm wavelength, 28vdc, 600hz pulse freq. The units also contain a receiver to detect reflected signals from targets. £199 Ref LOT4.

MAGNETIC CREDIT CARD READERS AND ENCODING MANUAL £9.95 Cased with flyleads, designed to read standard credit cards! complete with control elctronics PCB and manual covering everything you could want to know about whats hidden in that magnetic strip on your card! just £9.95 ref BAR31

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AUTO SUNCHARGER 155x300mm solar panel with diode and 3 metre lead and cigar plug. 12v 2w. **£12.99** REF AUG10P3.

STEPPER MOTORS Brand new stepper motors, 4mm fixing holes with 47.14mm fixing centres, 20mm shaft, 6.35mm diameter, 5v/phase, 0.7A/phase, 1.8 deg step (200 step) Body 56x36mm. £14.99 ea ref STEP6, pack of 4 for £49.95. PIC based variable speedcontroller kit £15 ref STEP7

200mpg from our new Velosolex motorized bikes £695 inc vat

Sales 01273 383848

Hydrogen fuel cells

Our new Hydrogen fuel cells are 1v at up tp 1A output, Hydrogen input, easily driven from a small electrolosis assembly or from a hydrogen source, our demo model uses a solar panel with the output leads in a glass of salt water to produce the hydrogen! Each cell is designed to be completely taken apart, put back together and expanded to what ever capacity you like, (up to 10watts and 12v per assembly. Cells cost £79 ref HFC11

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PHILIPS VP406 LASER DISC PLAYERS, SCART OUTPUT, JUST PUT YOUR VIDEO DISK IN AND PRESS PLAY, STANDARD AUDIO AND VIDEO OUTPUTS, FULLY TESTED AND WORKING. £24.95 REF VP406

SMOKE ALARMS Mains powered, made by the famous Gent company, easy fit next to light fittings ,power point. Pack of 5 £15 ref SS23, pack of 12 £24 ref SS24

4AH D SIZE NICADS pack of 4 £10 ref 4AHPK

SENDER KIT Contains all components to build a A/V transmitter complete with case £35 ref VSXX2

10 WATT SOLAR PANEL Amorphous silicon panel fitted in a anodized aluminium frame. Panel measures 3' by 1' with screw terminals for easy connection. . **3' x 1' solar panel £55 ref MAG45 Unframed 4 pack (3'x1') £58.99 ref SOLX**

12V SOLAR POWERED WATER PUMP Perfect for many 12v DC uses, from solar fountains to hydroponics! Small and compact yet powerful.works direct from our 10 watt solar panel in bright sun. Max hd:I7 ft Max flow = 8 Lpm,1 .5A Ref AC8 £18.99

SOLAR ENERGY BANK KIT 50x 6"x12" 6v solar panels(amorphous)+50 diodes £99 ref EF112

PINHOLE CAMERA MODULE WITH AUDIO!

Superb board camera with on board sound! extra small just 28mm square (including microphone) ideal for covert surveillance. Can be hidden inside anything , even a matchbox! Complete with 15 metre cable, psu and tv/vcr connnectors. £49.95 ref CC6J

SOLAR MOTORS Tiny motors which run quite happily on voltages from3-12vdc. Works on our 6v amorphous 6" panels and you can run them from the sun! 32mm dia 20mm thick. £1.50 each

WALKIE TALKIES 1 MILE RANGE £37/PAIR REF MAG30

LIQUID CRYSTAL DISPLAYS Bargain prices,
16 character 4 line, 62x25mm £5.99 ref SMC1640A
40 character 1 line 154x16mm £6.00 ref SMC4011A

YOUR HOME COULD BE SELF SUFFICENT IN ELECTRICITY Comprehensive plans with loads of info on designing systems, panels, control electronics etc £7 ref PV1

AUTO SUNCHARGER 155x300mm solar panel with diode and 3 metre lead and cigar plug. 12v 2w. **£12.99** REF AUG10P3.

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SOLAR NICAD CHARGERS 4 x AA size £9.99 ref 6P476, 2 x C size £9.99 ref 6P477

MINATURE TOGGLE SWITCHES These top quality Japanese panel mount toggle switches measure 35x13x12mm, are 2 pole changeover and will switch 1A at 250vac, or 3 A at 125vac. Complete with mounting washers and nuts. Supplied as a box of 100 switches for £29.95 ref SWT35 or a bag of 15 for £4.99 ref SWT34

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30 WATTS OF SOLAR POWER for just £69, 4 panels each one 3'x1' and producing 8w, 13v. PACK OF FOUR £69 ref SOLX

200 WATT INVERTERS plugs straight into your car cigarette lighter socket and is fitted with a 13A socket so you can run your mains operated devices from your car battery. £49.95 ref SS66

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33 KILO LIFT MAGNET Neodynium,32mm diameter with a fixing bolt on the back for easy mounting. Each magnet will lift 33 kilos, 4 magnets bolted to a plate will lift an incredible 132 kilos! £15 ref MAG33 Pack of 4 just £39 reg MAG33AA

HYDROGEN FUEL CELL PLANS Loads of information on hydrogen storage and production. Practical plans to build a Hydrogen fuel cell (good workshop facilities required) £8 set ref FCP1

STIRLING ENGINE PLANS Interesting information pack covering all aspects of Stirling engines, pictures of home made engines made from an aerosol can running on a candle! £12 ref STIR2

ENERGY SAVER PLUGS Saves up to 15% electricity when used with fridges, motors up to 2A, light bulbs, soldering irons etc. £9 ea ref LOT71, 10 pack £69 ref LOT72.

12V OPERATED SMOKE BOMBS Type 3 is a 12v trigger and 3 smoke cannisters, each cannister will fill a room in a very short space of time! £14.99 ref SB3. Type 2 is 20 smaller cannisters (suitable for mock equipment fires etc) and 1 trigger module for £29 ref SB2 Type 1 is a 12v trigger and 20 large cannisters £49 ref SB1

HI POWER ZENON VARIABLE STROBES Useful 12v PCB fitted with hi power strobe tube and control electronics and speed control potentiometer. Perfect for interesting projects etc 70x55mm 12vdc operation. £6 ea ref FLS1, pack of 10 £49 ref FLS2

NEW LASER POINTERS 4.5mw, 75 metre range, hand held unit runs on two AA batteries (supplied) 670nm. £29 ref DEC49J

HOW TO PRODUCE 35 BOTTLES OF WHISKY FROM A SACK OF POTATOES Comprehensive 270 page book covers all aspects of spirit production from everyday materials. Includes construction details of simple stills. £12 ref MS3

NEW HIGH POWER MINI BUG With a range of up to 800 metres and a 3 days use from a PP3 this is our top selling bug! less than 1" square and a 10m voice pickup range. £28 Ref LOT102.

IR LAMP KIT Suitable for cctv cameras, enables the camera to be used in total darkness! £6 ref EF138

INFRA RED POWERBEAM Handheld battery powered lamp, 4 inch reflector, gives out powerful pure infrared light! perfect for CCTV use, nightsights etc. £29 ref PB1.

SUPER WIDEBAND RADAR DETECTOR Detects both radar and laser, X K and KA bands, speed cameras, and all known speed detection systems. 360 degree coverage, front&rear waveguides, 1.1"x2.7"x4.6" fits on visor or dash £149

LOPTX Made by Samsung for colour TV £3 each ref SS52

LAPTOP LCD SCREENS 240x175mm, £12 ref SS51

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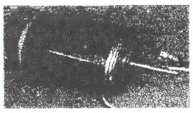
HIGH POWER DC MOTORS, PERMANENT MAGNET 12 - 24v operation, probably about 1/4 horse power, body measures 100m x 75mm with a 60mm x 5mm output shaft with a machined flat on it. Fixing is simple using the two threaded bolts protruding from the front. £22 ref MOT4



Online web catalogue bull-electrical.com

ELECTRONIC SPEED CONTROLLER KIT For the above motor is £19 ref MAG17. Save £5 if you buy them both together, 1 motor plus speed controller rrp is £41, offer price £36 ref MOT5A

INFRA RED REMOTE CONTROLS made for TV's but may have other uses pack of 100 £39 ref IREM

RCB UNITS Inline IEC lead with fitted RC breaker. Installed in seconds. Pack of 3 £9.98 ref LOT5A

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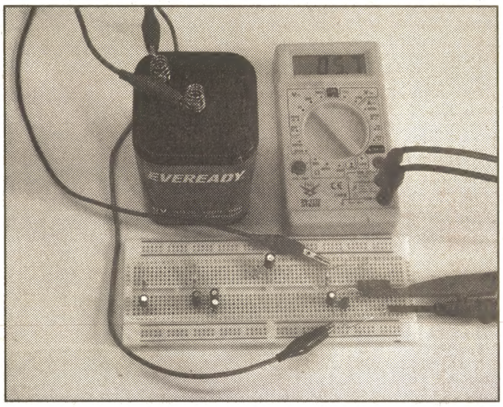

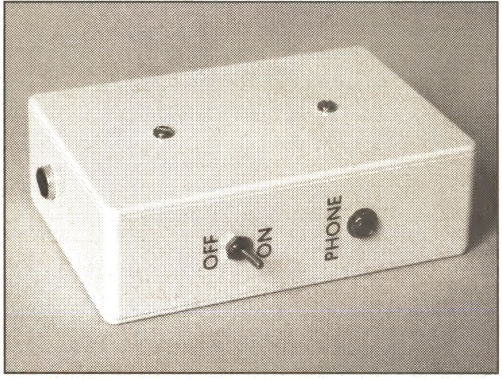

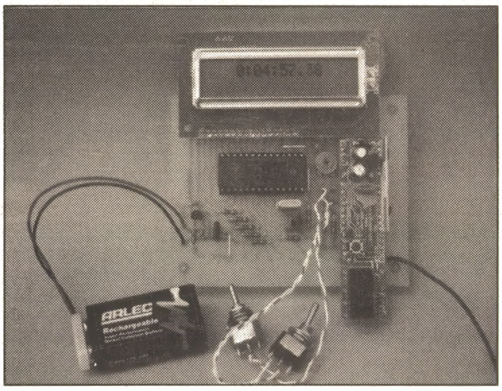

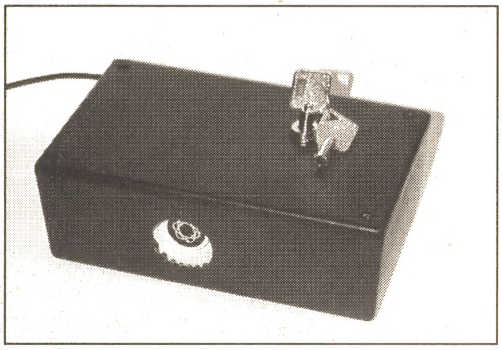

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Events timer with in-built l.c.d. and remote big digit displays, plus radio-controlled gating

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Multi-purpose vibration-triggered alarm with remarkable sensitivity

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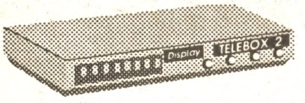

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For overseas PAL versions state 5.5 or 6 mHz sound specification. *For cable / hyperband signal reception Telebox MB should be connected to a cable type service. Shipping on all Telebox's, code (B)

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State of the art PAL (UK spec) **UHF TV tuner module** with **composite** 1V pp video & **NICAM** hi fi stereo sound outputs. **Micro electronics** all on one small PCB only 73 x 160 x 52 mm enable full tuning control via a **simple 3 wire link** to an IBM pc type computer. Supplied complete with **simple working program** and documentation. Requires +12V & + 5V DC to operate.

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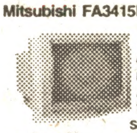

Mitsubishi FA3415ETKL 14" SVGA **Multisync** colour monitor with fine 0.28 dot pitch tube and resolution of 1024 x 768. A variety of inputs allows connection to a host of computers including **IBM PC's** in CGA, EGA, VGA & SVGA modes, **BBC, COMMODORE** (including Amiga 1200), **ARCHIMEDES** and **APPLE.** Many features: Etched faceplate, text switching and **LOW RADIATION MPR** specification. Fully guaranteed, in EXCELLENT little used condition.

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PHILIPS HCS35 (same style as CM8833) attractively styled 14" colour monitor with both **RGB and standard composite 15.625 Khz video inputs** via **SCART socket** and separate phono jacks. Integral audio **power amp and speaker** for **all audio visual uses.** Will connect direct to **Amiga and Atari** BBC computers. Ideal for all **video monitoring / security** applications with **direct connection to most colour cameras.** High quality with many features such as front concealed flap controls, VCR correction button etc. Good used condition - fully tested - guaranteed
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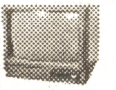

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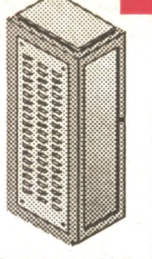

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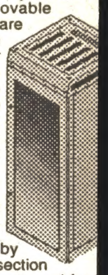

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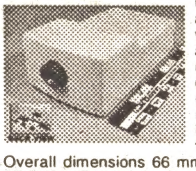

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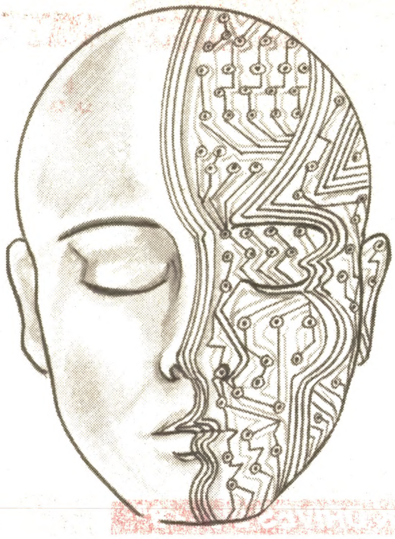
NEXT MONTH

SPECIAL IU SUPPLEMENT

Our Ingenuity Unlimited *section has always been very popular with readers, so we have put the pressure on Alan Winstanley to edit as many contributions as possible in order for us to provide you with a bumper bundle in the December issue. Some that we hope to present for your delectation and dismemberment are: Serial Port Splitter; Elderly Person Monitor; Audio Limiter; Rechargeable PP9 Battery; Shaky Dice; VCO Generator; Tumble Dryer Alarm; AA to PP3 Converter; Pulse Modulated Inverter; National Lottery Predictor and, just for good measure, a TV system using a simple modulator based on a Nipkow disc as made famous by one John Logie Baird some time ago.*



Starter Project

MAGNETIC FIELD DETECTOR

This very simple project can detect fixed magnetic fields or fields that are varying at an audio frequency. Fixed or slowly changing field strengths are registered on a centre-zero meter, which indicates the polarity in addition to the relative field strength. Audio frequency fields, such as those produced around mains and audio transformers, are detected via a crystal earphone that can be used to monitor the output signal.

The unit is not intended to provide accurate measurement of magnetic field strength, and is aimed at those who like to experiment with something a bit different. Although quite simple, the unit is reasonably sensitive. A small and not very powerful bar magnet can be detected by the prototype at about 100 millimetres from the sensor, and drives the reading to full scale at a range of about 30 millimetres.

TELECAN – A BRITISH FIRST IN HOME VIDEO RECORDING

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Britain stands pre-eminent in creative science and engineering, but the depressingly long list of "lost" British firsts in invention shows how often thwarted or disillusioned British inventors and innovators have either abandoned their ideas or gone abroad, thereby reducing British competitiveness. Decades of British under-investment in British ideas and British technologies has meant that other nations either independently develop the same ideas, or directly capitalise on British technical creativity – and soon overtake us in our markets.

Norman Rutherford and his partner Michael Turner have learnt this lesson and are quick to remind us. They should know; back in the early 1960's they not only developed the first domestic video record and replay system, but also the first combined TV and VTR and the first Camcorder; but poor foresight by their backers and investors lost them the edge. This is the story of their inventions.

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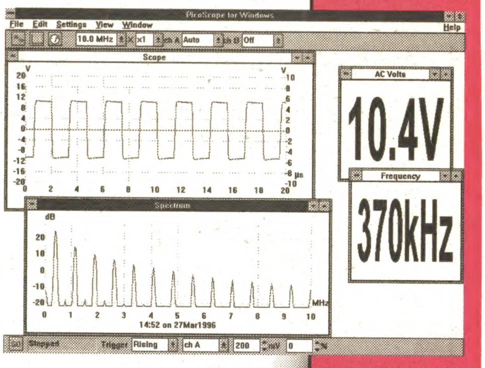

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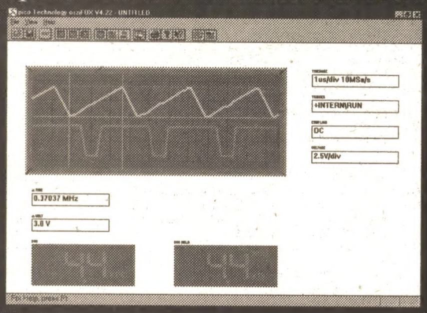

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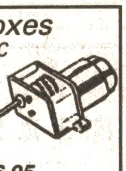

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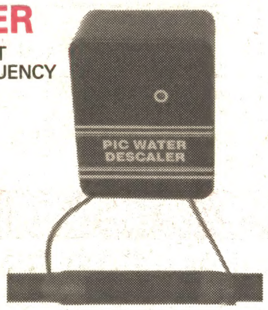

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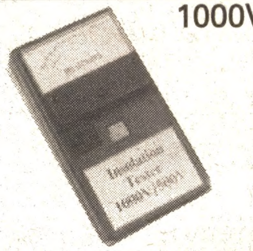

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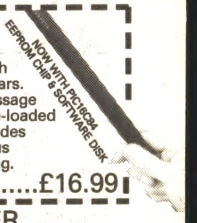
SPACEWRITER

An innovative and exciting project. Wave the wand through the air and your message appears. Programmable to hold any message up to 16 digits long. Comes pre-loaded with "MERRY XMAS". Kit includes PCB, all components & tube plus instructions for message loading.



KIT 849.......................£16.99

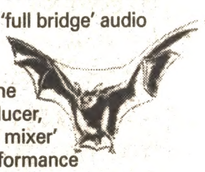
12V EPROM ERASER

A safe low cost eraser for up to 4 EPROMS at a time in less than 20 minutes. Operates from a 12V supply (400mA). Used extensively for mobile work – updating equipment in the field etc. Also in educational situations where mains supplies are not allowed. Safety interlock prevents contact with UV.

KIT 790...........................£29.90

SUPER BAT DETECTOR

1 WATT O/P, BUILT IN SPEAKER, COMPACT CASE
20kHz-140kHz
NEW DESIGN WITH 40kHz MIC.



A new circuit using a 'full bridge' audio amplifier i.c., internal speaker, *and* headphone/tape socket. The latest sensitive transducer, and 'double balanced mixer' give a stable, high peformance superheterodyne design.

KIT 861.......................£24.99
ALSO AVAILABLE Built & Tested £39.99

MOSFET MkII VARIABLE BENCH POWER SUPPLY 0-25V 2·5A.

Based on our Mk1 design and preserving all the features, but now with switching pre-regulator for much higher efficiency. Panel meters indicate Volts and Amps. Fully variable down to zero. Toroidal mains transformer. Kit includes punched and printed case and all parts. As featured in April 1994 *EPE*. An essential piece of equipment.

Kit No. 845................£64.95

EPE PROJECT PICs

Programmed PICs for all* EPE Projects
16C84/16F84/16C71
All **£5.90 each**
PIC16F877 now in stock
£10 inc. VAT & postage
(*some projects are copyright)

ULTRASONIC PEsT SCARER

Keep pets/pests away from newly sown areas, fruit, vegetable and flower beds, children's play areas, patios etc. This project produces intense pulses of ultrasound which deter visiting animals.

- KIT INCLUDES ALL COMPONENTS, PCB & CASE
- EFFICIENT 100V TRANSDUCER OUTPUT
- COMPLETELY INAUDIBLE TO HUMANS
- UP TO 4 METRES RANGE
- LOW CURRENT DRAIN

KIT 812...£15.00

SIMPLE PIC PROGRAMMER

INCREDIBLE LOW **PRICE!** **Kit 857 £12.99**

INCLUDES 1-PIC16F84 CHIP
SOFTWARE DISK, LEAD
CONNECTOR, PROFESSIONAL
PC BOARD & INSTRUCTIONS

Power Supply £3.99

EXTRA CHIPS:
PIC 16F84 £4.84

Based on February '96 *EPE.* Magenta designed PCB and kit. PCB with 'Reset' switch, Program switch, 5V regulator and test L.E.D.s, and connection points for access to all A and B port pins.

PIC16C84 LCD DISPLAY DRIVER

INCLUDES 1-PIC16F84
WITH DEMO PROGRAM
SOFTWARE DISK, PCB,
INSTRUCTIONS AND
16-CHARACTER 2-LINE
LCD DISPLAY

Kit 860 **£19.99**

Power Supply £3.99

FULL PROGRAM SOURCE
CODE SUPPLIED – DEVELOP
YOUR OWN APPLICATION!

Another super PIC project from Magenta. Supplied with PCB, industry standard 2-LINE x 16-character display, data, all components, and software to include in your own programs. Ideal develpment base for meters, terminals, calculators, counters, timers – Just waiting for your application!

PIC16F84 MAINS POWER 4-CHANNEL CONTROLLER & LIGHT CHASER

- WITH PROGRAMMED 16F84 AND DISK WITH SOURCE CODE IN MPASM
- ZERO VOLT SWITCHING MULTIPLE CHASE PATTERNS
- OPTO ISOLATED 5 AMP OUTPUTS
- 12 KEYPAD CONTROL
- SPEED/DIMMING POT.
- HARD FIRED TRIACS

Now features full 4-channel chaser software on DISK and pre-programmed PIC16F84 chip. Easily re-programmed for your own applications. Software source code is fully 'commented' so that it can be followed easily.

Kit 855 **£39.95**

LOTS OF OTHER APPLICATIONS

PIC TOOLKIT V1

• PROGRAMS PIC16C84 and 16F84 • ACCEPTS TASM AND MPASM CODE
Full kit includes PIC16F84 chip, top quality p.c.b. printed with component layout, turned pin PIC socket, all components and software*
*Needs QBASIC or QUICKBASIC

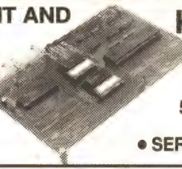
KIT 871 . . . £13.99. Built and tested **£21.99**

PhizzyB ALL PARTS FOR SERIES INCLUDING PCBs, PROGRAMMED CHIP, CD-ROM AND DISPLAYS

MAIN BOARD – FULL KIT	**£131.95**	BUILT	**£149.95**
I/O PORT KIT	**£16.99**	BUILT	**£24.99**
L.C.D.	**£12.49**	POWER SUPPLY ..	**£3.99**
8-BIT SWITCH/LATCH	**£7.95**	INT. MODULE .	**£10.45**

68000 DEVELOPMENT AND TRAINING KIT

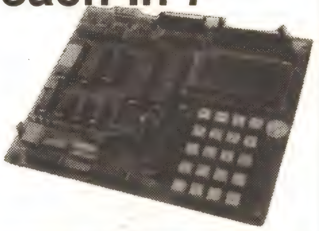
KIT 621
£99.95



- NEW PCB DESIGN
- 8 MHz 68000 16-BIT BUS
- MANUAL AND SOFTWARE
- 2 SERIAL PORTS
- PIT AND I/O PORT OPTIONS
- I2C PORT OPTIONS

• ON BOARD 5V REGULATOR
• PSU £6.99
• SERIAL LEAD £3.99

Mini-Lab & Micro Lab
Electronics Teach-In 7



As featured in *EPE* and now published as Teach-In 7. All parts are supplied by Magenta.
Teach-In 7 is £3.95 from us or *EPE*
Full Mini Lab Kit – £119.95 –
Power supply extra – £22.55
Full Micro Lab Kit – £155.95
Built Micro Lab – £189.95

EPE PIC Tutorial

At Last! A Real, Practical, Hands-On Series

- Learn Programming from scratch using PIC16F84
- Start by lighting l.e.d.s and do 30 tutorials to Sound Generation, Data Display, and a Security System
- PIC TUTOR Board with Switches, l.e.d.s, and on board programmer

PIC TUTOR BOARD KIT

Includes: PIC16F84 Chip, TOP Quality PCB printed with Component Layout and all components* (*not ZIF Socket or Displays). Included with the Magenta Kit is a disk with Test and Demonstration routines.

KIT 870 ...... £27.95, Built & Tested £42.95
Optional: **Power Supply – £3.99, ZIF Socket – £9.99**
LCD Display ....£7.99 LED Display £6.99

PIC TOOLKIT V2

- SUPER UPGRADE FROM V1 • 18, 28 AND 40-PIN CHIPS
- READ, WRITE, ASSEMBLE & DISASSEMBLE PICS
- SIMPLE POWER SUPPLY OPTIONS 5-20V
- ALL SWITCHING UNDER SOFTWARE CONTROL
- MAGENTA DESIGNED PCB HAS TERMINAL PINS AND OSCILLATOR CONNECTIONS FOR ALL CHIPS
- INCLUDES SOFTWARE AND PIC CHIP

KIT 878 . . . £22.99 with 16F84 . . . £29.99 with 16F877

SUPER PIC PROGRAMMER

- READS, PROGRAMS, AND VERIFIES
- WINDOWS™ SOFTWARE
- PIC16C6X, 7X, AND 8X
- USES ANY PC PARALLEL PORT
- USES STANDARD MICROCHIP • HEX FILES
- OPTIONAL DISASSEMBLER SOFTWARE (EXTRA)
- PCB, LEAD, ALL COMPONENTS, TURNED PIN SOCKETS FOR 18, 28, AND 40 PIN ICs.

• SEND FOR DETAILED INFORMATION – A SUPERB PRODUCT AT AN UNBEATABLE LOW PRICE.

Kit 862 **£29.99**

Power Supply £3.99

DISASSEMBLER SOFTWARE £11.75

PIC STEPPING MOTOR DRIVER

INCLUDES: PCB,
PIC16F84 WITH
DEMO PROGRAM,
SOFTWARE DISK,
INSTRUCTIONS
AND MOTOR.

Kit 863 **£18.99**

FULL SOURCE CODE SUPPLIED.
ALSO USE FOR DRIVING OTHER
POWER DEVICES e.g. SOLENOIDS.

Another NEW Magenta PIC project. Drives any 4-phase unipolar motor – up to 24V and 1A. Kit includes all components and 48 step motor. Chip is pre-programmed with demo software, then write your own, and re-program the same chip! Circuit accepts inputs from switches etc and drives motor in response. Also runs standard demo sequence from memory.

8-CHANNEL DATA LOGGER

NEW!

As featured in Aug./Sept. '99 *EPE.* Full kit with Magenta redesigned PCB – LCD fits directly on board. Use as Data Logger *or* as a test bed for many other 16F877 projects. Kit includes programmed chip, 8 EEPROMs, PCB, case and all components.

KIT 877 £49.95 inc. 8 x 256K EEPROMS

MAGENTA

All pricesinclude VAT. Add **£3.00** p&p. Next Day **£6.99**

Tel: 01283 565435 Fax: 01283 546932 E-mail: sales@magenta2000.co.uk

1199

ESR ELECTRONIC COMPONENTS

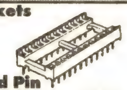
Station Road, Cullercoats,
Tyne & Wear, NE30 4PQ

All Major Credit cards Accepted

Prices Exclude Vat @17½%. Add £1.25 carriage & Vat to all orders. Cheques / Postal orders payable to ESR Electronic Components.

See Next / Last Months Ad. for COMPONENT ACCESSORIES

DIL Sockets



Stamped Pin

6 Pin DIL 0.3"	£0.06
8 Pin DIL 0.3"	£0.06
14 Pin DIL 0.3"	£0.11
16 Pin DIL 0.3"	£0.11
18 Pin DIL 0.3"	£0.12
20 Pin DIL 0.3"	£0.12
24 Pin DIL 0.6"	£0.13
28 Pin DIL 0.6"	£0.13
40 Pin DIL 0.6"	£0.19

Turned Pin

8 Pin DIL 0.3"	£0.11
14 Pin DIL 0.3"	£0.20
16 Pin DIL 0.3"	£0.23
18 Pin DIL 0.3"	£0.25
20 Pin DIL 0.3"	£0.28
24 Pin DIL 0.6"	£0.35
28 Pin DIL 0.6"	£0.41
40 Pin DIL 0.6"	£0.64

0.1" Pin Header Strip

1 x 36 Way Straight	£0.38
2 x 36 Way Straight	£0.56
1 x 36 Way 90°	£0.54
2 x 36 Way 90°	£0.80

Available in 2,3,4,5 & 10 way. Also female PCB sockets & jumper links.

20 Way Socket Strip	£0.48

Transistor Sockets

T018-4 Base Socket	£0.24
T05 Base Socket	£0.24

IDC Cable Sockets

10 Way Socket	£0.25
14 Way Socket	£0.35
16 Way Socket	£0.37
20 Way Socket	£0.37
26 Way Socket	£0.38
34 Way Socket	£0.39
40 Way Socket	£0.55
50 Way Socket	£0.80

PCB Box Headers

10 Way Straight	£0.27
14 Way Straight	£0.36
16 Way Straight	£0.36
20 Way Straight	£0.32
26 Way Straight	£0.57
34 Way Straight	£0.57
40 Way Straight	£0.63
50 Way Straight	£0.96
10 Way 90°	£0.33
16 Way 90°	£0.42
20 Way 90°	£0.53
26 Way 90°	£0.70
34 Way 90°	£0.81
40 Way 90°	£0.83
50 Way 90°	£0.95

PCB Latch Headers

10 Way Straight	£0.50
16 Way Straight	£0.70
20 Way Straight	£0.78
26 Way Straight	£0.81
34 Way Straight	£0.86
40 Way Straight	£1.56
50 Way Straight	£1.29
10 Way 90°	£0.58
16 Way 90°	£0.78
20 Way 90°	£0.82
26 Way 90°	£1.06
34 Way 90°	£1.14
40 Way 90°	£1.26
50 Way 90°	£1.74

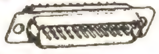
DIL Headers

14 Way DIL	£0.54
16 Way DIL	£0.59
24 Way DIL	£0.90
40 Way DIL	£1.02

Transistion Headers

10 Way Transistion	£0.49
14 Way Transistion	£0.47
16 Way Transistion	£0.47
20 Way Transistion	£0.54
26 Way Transistion	£0.62
34 Way Transistion	£0.67
40 Way Transistion	£0.90
50 Way Transistion	£1.02

D Type Connectors



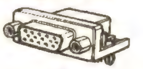
Solder Bucket

9 Way Male Plug	£0.26
9 Way Female Socket	£0.27
15 Way Male Plug	£0.36
15 Way Female Socket	£0.39
15 Way H.D. Plug	£0.47
15 Way H.D. Socket	£0.78
23 Way Male Plug	£0.49
23 Way Female Socket	£0.49
25 Way Male Plug	£0.36
25 Way Female Skt	£0.37

IDC Ribbon Mounting

9 Way Male Plug	£1.08
9 Way Female Socket	£0.93
25 Way Male Plug	£1.18
25 Way Female Socket	£1.13

Right Angled PCB

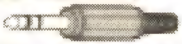


9 Way Male Plug	£0.37
9 Way Female Socket	£0.35
15 Way H.D. Socket	£0.77
25 Way Male Plug	£0.53
25 Way Female Socket	£0.51

Plastic D Covers

9 Way Cover - Grey	£0.30
9 Way Cover - Black	£0.30
15 Way Cover - Grey	£0.33
23 Way Cover - Grey	£0.36
23 Way Cover - Black	£0.36
25 Way Cover - Grey	£0.34
25 Way Cover - Black	£0.37
9 to 9 Cover / Case	£0.96
25 to 25 Cover / Case	£0.84
9 to 25 Cover / Case	£0.96

Audio Connectors



2.5mm Jack Plug	£0.21
2.5mm Line Socket	£0.16
2.5mm Chassis Socket	£0.20
3.5mm Mono Plug	£0.24
3.5mm Mono Line Skt	£0.30
3.5mm Mono Chassis	£0.14
3.5mm Stereo Plug	£0.36
3.5mm Stereo Line Skt	£0.37
3.5mm Stereo Chassis	£0.34
¼" Mono Plug	£0.34
¼" Mono Line Socket	£0.35
¼" Mono Chassis Sk	£0.35
¼" Stereo Plug	£0.40
¼" Stereo Line Socket	£0.38
¼" Stereo Chassis Skt	£0.40
NEUTRIK Speakon Plug	£2.81

DIN Series

2 Pin Line Plug	£0.19
2 Pin Chassis Socket	£0.15
3 Pin Line Plug	£0.27
3 Pin Chassis Socket	£0.28
4 Pin Line Plug	£0.24
4 Pin Chassis Socket	£0.26
5 Pin Line Plug 180°	£0.30
5 Pin Chassis Skt 180°	£0.33
5 Pin Line Plug 240°	£0.24
5 Pin Chassis Skt 240°	£0.32
5 Pin Line Plug 360°	£0.24
5 Pin Chassis Skt 360°	£0.32
6 Pin Line Plug	£0.34
6 Pin Chassis Socket	£0.35
7 Pin Line Plug	£0.35
7 Pin Chassis Socket	£0.37
8 Pin Line Plug	£0.44
8 Pin Chassis Socket	£0.36

Phono Series

Red Line Plug	£0.20
Black Line Plug	£0.20
Yellow Line Plug	£0.20
White Line Plug	£0.20
Red Line Socket	£0.20
Black Line Socket	£0.20
Yellow Line Socket	£0.20
White Line Socket	£0.20
Red Chassis Socket	£0.20
Black Chassis Socket	£0.20
Gold Plated Plug Red	£0.66
Gold Plated Plug Black	£0.66

XLR Series - metal

3 Pin Line Plug	£1.46
3 Pin Line Socket	£1.71
3 Pin Chassis Plug	£1.50
3 Pin Chassis Socket	£1.49
Neutrik Line Plug	£1.68
Neutrik Line Socket	£1.99
Neutrik Chassis Plug	£2.13
Neutrik Chassis Socket	£2.32

RF Connectors

BNC Plug 50Ω Solder	£0.99
BNC Plug 50Ω Crimp	£0.68
BNC Plug 75Ω Solder	£0.95
BNC Plug 75Ω Crimp	£0.68
BNC Chassis Socket	£0.81
F Plug - Twist	£0.24
F Plug - Crimp	£0.26
TNC Plug 50Ω Solder	£1.24
TNC Plug 50Ω Crimp	£0.85
TNC Plug 75Ω Solder	£1.40
TNC Plug 75Ω Crimp	£1.16
UHF Plug 5mm Cable	£0.63
UHF Plug 11mm Cable	£0.75
UHF Chassis Skt- Sqr	£0.50
UHF Chassis Skt- Rnd	£0.73

Extensive range of RF connectors in stock, inc.FME, SMA, Mini UHF & N Type.

Terminals

Colours Red, Black, Green, Blue, White or Yellow

2mm Solder Plugs	£0.18
2mm Chassis Sockets	£0.26
4mm Solder Plugs	£0.35
4mm Stackable Plugs	£0.40
4mm Chassis Sockets	£0.23
4mm Binding Posts	£0.54
33mm Crocodile Clips	£0.13

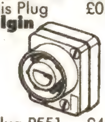
Power Connectors
DC Low Voltage

DC Plug 0.7ID 2.35OD	£0.47
DC Plug 1.3ID 3.4OD	£0.32
DC Plug 1.7ID 4.0OD	£0.47
DC Plug 1.7ID 4.75OD	£0.47
DC Plug 2.1ID 5.0OD	£0.25
DC Plug 2.5ID 5.0OD	£0.24
DC Plug 3.1ID 6.3OD	£0.46
DC Line Socket 2.1mm	£0.57
DC Line Socket 2.5mm	£0.56
DC Chassis Skt 2.1mm	£0.40
DC Chassis Skt 2.5mm	£0.41

IEC Mains 6A 250Vac

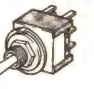
3 Pin IEC Line Socket	£1.08
3 Pin IEC Line Plug	£1.78
3 Pin Chassis Socket	£0.55
3 Pin Chassis Plug	£0.72

8 Way Bulgin



8 Pin Line Plug P551	£4.08
8 Pin Chassis Skt P552	£1.39

Toggle Switches



Sub-Miniature

3A 125V 1A 250V
5mm Ø Mounting Hole

SPST 5 x 10mm	£0.58
SPDT 5 x 10mm	£0.60
SPDT C/Off 5 x 10mm	£0.81
DPDT 9.2 x 10mm	£0.66

Miniature

6A 125V 3A 250V
6.2mm Ø Mounting Hole

SPST 8 x 13mm	£0.65
SPDT 8 x 13mm	£0.56
SPDT c/off 8 x 13mm	£0.60
SPDT c/o Biased 2 way	£0.97
SPDT c/o Biased 1 way	£1.04
DPDT 12 x 13mm	£0.72
DPDT c/off 12 x 13mm	£0.80
DPDT c/o Biased 2 way	£1.28
DPDT c/o Biased 1 way	£1.28

Standard

10A 250V Push on terminals
12mm Ø Mounting Hole

SPST 18 x 30mm	£1.28
SPDT 18 x 30mm	£1.31
SPDT c/off 18 x 30mm	£1.43
DPDT 21 x 30mm	£1.65
DPDT c/off 21 x 30mm	£1.68

Slide Switches

Miniature

300mA 125V
7 x 15mm Mounting Hole

DPDT 7 x 23mm	£0.20

Standard

1A 125V
5.5 x 12mm Mounting Hole

DPDT 12 x 35mm	£0.25
DPDT c/o 12 x 35mm	£0.27

Rotary Switches

150mA 250V
Make before Break 22mm Ø
9.8mm Ø Mounting Hole

1 Pole 12 Way	£0.84
2 Pole 6 Way	£0.84
3 Pole 4 Way	£0.84
4 Pole 3 Way	£0.84

Push Switches

Miniature Round

250mA 125V 28 x 10mm
7mm Ø Mounting Hole
Non Latching Push to Make

Black PTM	£0.23
Red PTM	£0.23
Yellow PTM	£0.23
Green PTM	£0.23
Blue PTM	£0.23
White PTM	£0.23

Non Latching Push to Break

Black PTB	£0.24

Standard Square

1A 250V
39 x 15MM
12mm Ø Mounting Hole
Non Latching Push to Make

Black PTM	£0.60
Red PTM	£0.60
Blue PTM	£0.60
White PTM	£0.60

Latching -push On push Off

Black	£0.65
Red	£0.65
Blue	£0.65
White	£0.65

Rocker Switches

Miniature

6A 250V Solder Tags

SPST 21 x 14 x 16mm	£0.69
DPDT 21 x 24 x 22mm	£0.96
SPST - Red Neon	£1.02
SPST - Green Neon	£1.02
SPST - Amber Neon	£1.02

Standard

15A 250V Push on Tags

SPST 30 x 11 x 22mm	£0.58
DPDT 30 x 25 x 22mm	£1.12

Illuminated

15A 250V Push on Tags

SPST 30x14mm Red	£0.84
DPST 30x25mm Amber	£1.40
DPST 30x25mm Green	£1.40

Relays

PCB Mounting

1A 24Vdc DPDT 5V	£1.38
1A 24Vdc DPDT 12V	£2.00
3A 110V SPDT 6V	£0.58
3A 110V SPDT 12V	£0.58
5A 110V SPDT 6V	£0.72
5A 110V SPDT 12V	£0.72
5A 110V DPDT 6V	£0.93
5A 110V DPDT 12V	£0.93
5A 240V DPDT 6V	£1.76
5A 240V DPDT 12V	£1.76
10A 240V SPDT 6V	£1.25
10A 240V SPDT 12V	£1.44
10A 240V SPDT 24V	£1.44

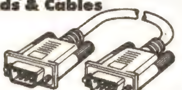
Computer Accessories
Adaptors

9M Gender Changer	£2.18
9F Gender Changer	£2.29
25M Gender Changer	£2.60
25F Gender Changer	£2.80
9 Male - 25 Female	£1.90
9 Female - 25 Male	£1.90
9M - 6 Mini Din Male	£2.40
9F - 6 Mini Din Female	£2.40
5M Din - 6F Mini Din	£2.08
5F Din - 6M Mini Din	£2.08

Testers / Patch Boxes

Mini Tester 7 LEDs	£4.72
Check Tester 18 LEDs	£6.32
Enhanced + Switches	£15.25
25D Jumper Box M-F	£2.90
25D Patch Box M-F	£7.32
Anti-Static Wrist Strap	£4.76
RS232 Surge Protector	£5.43
Mains Surge Protector	£11.99
4 Gang Surge Block	£15.50

Leads & Cables



1.5m Printer Lead	£3.40
5m Printer Lead	£9.38
10m Printer Lead	£8.75
Serial Printer 25M-9F	£4.50
Serial Printer 25M-25F	£4.45

Null Modem Leads

9 Female - 9 Female	£3.16
25 Female- 25 Female	£4.63
9 Female - 25 Female	£3.18
9&25F to 9&25F	£5.52

Modem Leads

25Male to 9Female	£4.08
25Male to 25Female	£4.75

PC Link Leads

Interlink 25M to 25M	£4.38

Patch Lead

25Male to 25Male	£4.50
36Male to 36Male	£2.60

Internal Leads

Floppy Cable A/B	£3.00
Hard Disk 2xIDE	£1.65
Power 3½-2 x 3½	£1.88
Power 5¼-2 x 5¼	£1.50
Power 5¼-2 x 3½	£2.24
Power 5¼-3½,5¼	£2.24

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VOL. 28 No. 11 NOVEMBER '99

GIVE PICS A CHANCE

It seems some of our readers are definitely not interested in PICs. They see any PIC project as being computer orientated and they don't want those dreadful machines impinging on their hobby of electronics. Well, I'm here to tell you that you don't need to have any contact with a computer to build the vast majority of our PIC projects. You don't need to understand DOS or Windows or any of that computer babble, you just need to be able to wield a soldering iron and follow our constructional information.

The black art of actually programming the chip need not worry you any more than the design of the silicon inside a 555 or even the atomic level interaction in an OC71 (if you have never heard of one of those, don't worry 'cos you probably never will again).

Unfortunately, the world moves forward and the fact that we have exciting new chips that will allow our projects to perform ever more complex tasks, whilst staying simple to build, should be a bonus. (I should point out that PICs are not that new, even to the hobbyist; our first PIC based project appeared in *EPE* in June 1992 and we have been sent a General Instruments data book that shows they were selling PIC chips in 1982.)

BLOWING A FUSE

It's not a matter of blowing internal fusible links, or handling unreliable static sensitive devices that will "fall over" as soon as you look at them. PICs are robust, easy to use chips that have, along with other microcontrollers, revolutionised the world of electronics. So, please don't be frightened of them – we understand if you don't want to know about the software or the programming – just give them a try, we are sure you will find they are just like any other chip if you buy them preprogrammed. If, however, you then decide you might just be interested in making a PIC do what you want it to then a whole new fascinating world might just open up for you.

If you want to understand more about electronics in general, then our new *Teach-In 2000* series starting this month will be invaluable. There is also some free software to help you along but of course it's not essential if you are "computer shy".

By the way, don't worry about what PIC stands for – PIC is simply the prefix given to a range of microcontroller i.c.s made by Microchip. Millions of them are in use in commercial products all over the world and thousands of them are being used by hobbyists every day.

Mike Kenward

AVAILABILITY

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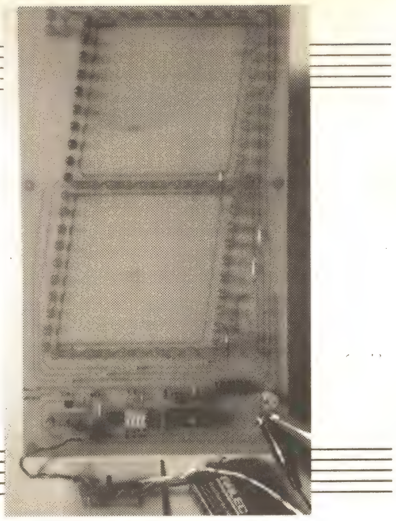
Constructional Project

GINORMOUS STOPWATCH

NED STOJADINOVIC

Part 1



Automatically times sporting events up to ten hours with a resolution of 1/100th of a second.

THE circuit presented here is a modernised version of a stopwatch designed and built by the author several years ago to time equestrian events where the start and stop gates were not readily visible to the timekeepers, necessitating some sort of remote triggering to get reasonable accuracy.

Also included is a large display unit so that the audience can be a part of the action – their hero has two fences to go and the clock is ticking, will he beat the current best time . . .

NEW TECHNOLOGY

This design is something of an object lesson in just how far hobby electronics has come in the last few years.

The first stopwatches the author built were entirely from discrete components and comprised several circuit boards all performing a single function. There was a clock generator board, two separate light emitting diode (l.e.d.) drivers, transmitter/receiver boards and various miscellaneous bits to glue them all together.

Needless to say, the whole device was a monster and required the services of a lead acid battery the size of half a house brick to keep it all running. Also needless to say, it cost a fortune to produce!

The current design uses a single PIC16C55 to generate all the timing and liquid crystal display (l.c.d.) functions. The transmitter/receiver sections are comprised of small commercial modules, complete with channel coding/decoding facilities.

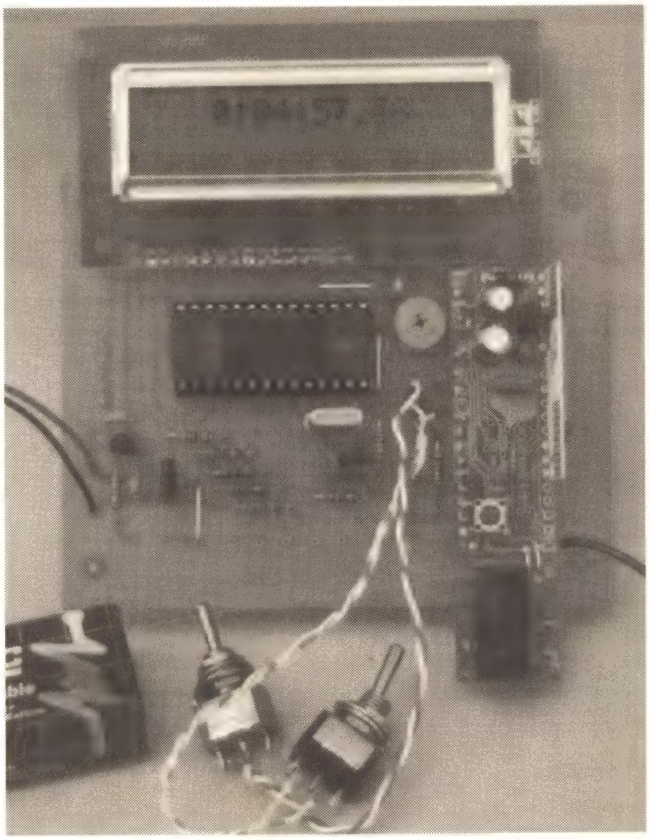
Furthermore, instead of a lead acid battery that could easily start a small car, a standard 9V cell is used. Oh, and the Stopwatch module outputs serial data for the Large Digit Display to-boot!

DESIGN OVERVIEW

The basic Stopwatch is fairly standard with the usual Start, Stop and Lap functions that can be triggered by pushbutton switches. The maximum time is ten hours (9:59:59·99 where the last digit is hundredths of a second).

There is an integral display on the main controller board, using an alphanumeric liquid crystal module, which can either be 16 characters by one line (16 × 1) or 16 characters by two lines (16 × 2), either will work.

As an optional extra feature, the design includes a radio control function. Two transmitters can be used in conjunction with optical "gate" detection units. The transmitters are of a type approved in the UK and operate on 418MHz using amplitude modulation (a.m.).



Photograph of the author's prototype test model of the Stopwatch control board. in the final version described additional switches are included. The relay on the receiver module (r.h.s. of photo) is not used.

The optical gate units are basically "door minders", the same as you might see in the doorway of shops. In normal operation, the beam units will transmit a coded signal to the Stopwatch module when the beam is broken, and the code will specify which beam was broken, i.e. Stop or Start.

The 418MHz receiver module on the Stopwatch assembly includes its own decoders which allow two channel operation, where one channel is Start and the other is Stop. In use, the receiver is taught the code of the transmitters following the method outlined in their respective data sheets.

Ensure that you obtain data sheets for the transmitters, receiver and "door minders" when you order them.

Note that the Lap function is only available via a pushbutton switch.

Another special feature of the Stopwatch design is the serial output for the Large Digit Display unit, which will be described next month.

The serial output runs at 9600 bits/sec with N,8,1 protocol (no parity, eight bits and one stop bit). The physical design is exactly the same as used by musical instruments in the MIDI standard, which specifies everything linked together by optocouplers, making for a very rugged and almost foolproof piece of apparatus.

BRAIN BOX

As the PIC microcontroller is the brain of the outfit, we start with a discussion of this aspect of the design.

The fundamental part of the software is in the use of the RTCC (real time clock counter) to generate 0·01 (one hundredth) second clock signals, or 100Hz. Taking the easiest option, a 3·2768MHz crystal is used to generate the microcontroller's basic control frequency, which is then divided internally by four by the micro to produce an intermediate clock rate of 819200Hz.

Now the PIC's prescaler function is used to divide by 16 to give 51200Hz. Then the RTCC divides by 256 to give 200Hz, which is a period of 0·005 seconds, where twice 0·005 gives us the desired 0·01 seconds clock rate. The software reads and responds to the status of the RTCC, but never writes to it (an action which can create timing accuracy problems).

If you refer to the source code (see later), you will see that the main program loop is simply checking the position of the push-button switches and radio control signals. The prescale value of 16 means that every value of the RTCC counter will be held for 16 clock cycles.

In practical terms, the main program loop must have less then 16 cycles before testing for RTCC equalling zero (i.e. the RTCC rollover). Once the RTCC rollover has been detected, there are around 255 × 16 (4080) cycles in which to perform other parts of the program.

With the clock rate established, it is a simple matter of dividing it down by tens to get tenths and seconds, then by 60 to get minutes, etc., the only complication being that the l.c.d. demands numbers in ASCII format. In fact, this is quite easy to resolve as it simply means that a value of 30h (hexadecimal – 48 decimal) has to be added to the counter values.

This could have been done in the l.c.d. drive subroutine but it was just as easy to manipulate the counters with the 30h added.

DRIVING THE L.C.D.

The author claims no credit for the l.c.d. driving subroutine – he lifted it complete from a Parallax application note which is available from their web site at **www.parallaxinc.com**. It is strongly suggested that you have a good browse, especially the l.c.d. notes which are excellent.

It should also be mentioned that the main aim of any programmer is not to write any software unless forced into it, there is no percentage in recreating the wheel – unless, of course, you are learning to make wheels!

SERIAL OUTPUT

The serial output was rather more complicated due to timing limitations. There is simply not enough time to update the l.c.d. and the large display and get back in time for the RTCC rollover.

After much head scratching it was decided to do what all programmers must eventually do – cheat! Since the human eye cannot really follow numbers changing at one hundred times a second, it seemed that the display would probably look the same if it simply showed the number "8" while the stopwatch was running, but updating everything when it was stopped.

As far as can be determined, it works and nobody has come up and said "Oi, yer hundredths ain't runnin' proper".

Of course, it was not as simple as that due to the Lap function. Once the clock is stopped it doesn't matter how long it takes to update the displays (where *long* is measured in hundredths of a second) because the RTCC is halted, but freezing the display for a Lap requires an update while checking for RTCC rollover.

The solution was to check the RTCC value before calling the l.c.d. driver subroutine and vetoing the call if the rollover was getting close. This necessitated a whole heap of flags to mark the digits that have been updated, but seems to work quite smoothly.

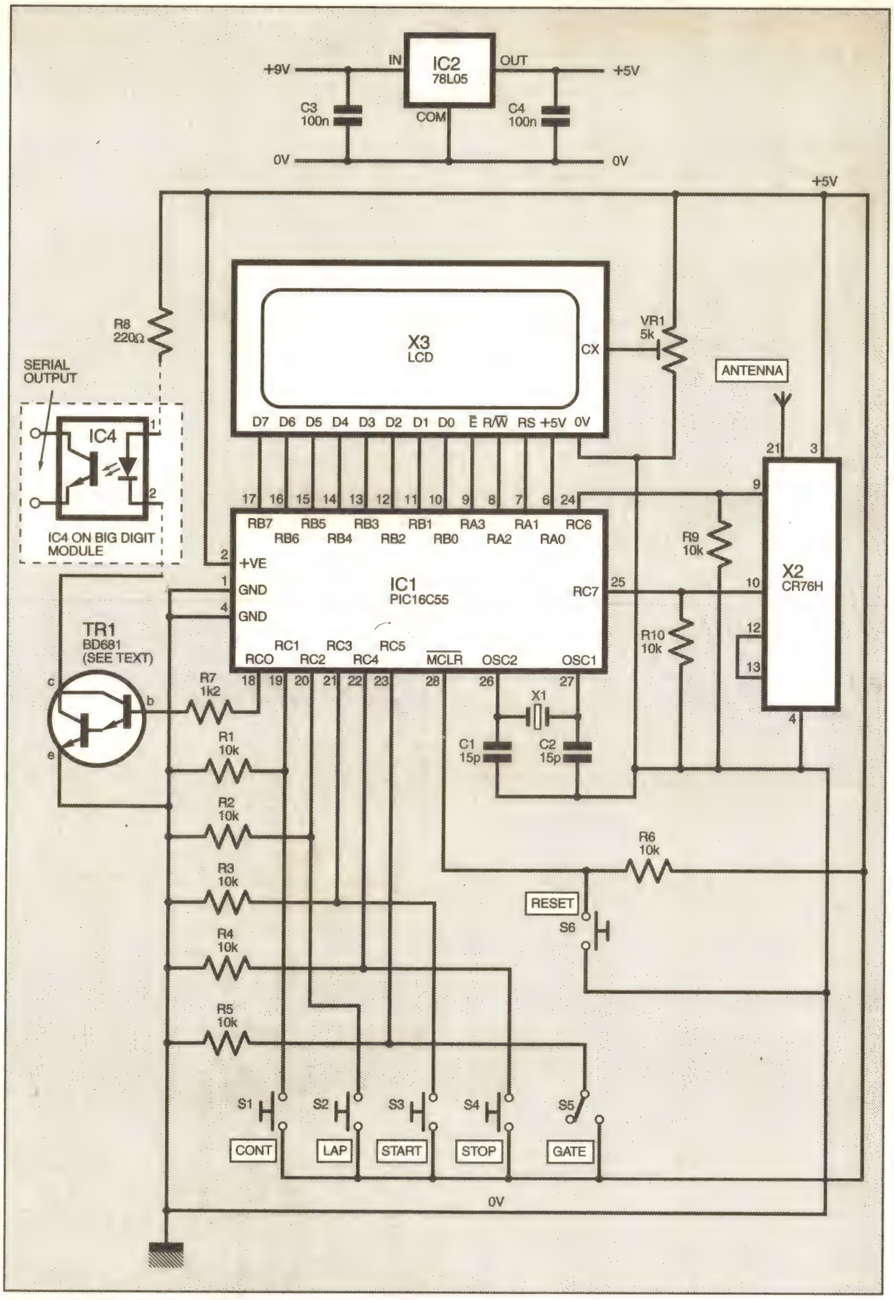


Fig.1. Complete circuit diagram for the Ginormous Stopwatch control module. Note that IC4 is part of the Large Digit Display unit described next month.

Note again that the serial output routine started life as a Parallax application note and you should have a look at their excellent description of the serial communications protocol.

MIDI STANDARD

As regular *EPE* readers will know, the MIDI standard specifies a very good way to send serial data from one electronic musical instrument to another. The MIDI standard was probably implemented to allow musicians to be very careless of connections with a high degree of impunity! It seems to work well.

The receiving instrument has an opto-coupler isolating it from the outside world – there is no electrical connection to the sending instrument. The sending instrument supplies the power to drive the l.e.d. within the optoisolator.

In the stopwatch module, as shown in the circuit diagram of Fig.1, when transistor TR1 is switched on by the PIC, current flows from the 5V power supply, through resistor R8 and optoisolator IC4 and finally to ground (0V) through TR1. Note that IC4 is actually part of the Large Digit Display to be described next month.

U.H.F. CONTROLLER

Living in this era is great, all you have to do is draw a box marked "UHF Module" and move onto the next part of the design. The module used here is a complete u.h.f. receiver which includes internal functions which decode the received signal and, when the code received matches that of one of the decoders, produces a logic low on the appropriate output pin (pin 9 or pin 10), which is fed directly into the PIC (pin 24 or pin 25, respectively).

Note that the u.h.f. unit you receive may have outputs that are normally low, i.e. pressing the radio transmitter buttons will make the output go to 5V. This is not a problem as the software only looks for a change of state, either 0V to 5V or 5V to 0V, but note the comments at the end of the "Testing" section.

OPTICAL GATES

Since the reinvention of the wheel was not a high priority, the author used commercially available "door minders" as the optical gates. The design used by the author uses a modern integrated component to do all the dirty work of modulating/sending and then receiving/demodulating the infrared beam.

One of the interesting parts of this particular design used by the author is the way the beam is doubly modulated to avoid false triggering. This is spelled out in the data sheet that accompanies the module.

In practice, any "door minder" can be used if local sources are more convenient. (See *Shoptalk* for suppliers.) Pretty much all of them use an output relay and it is a simple task to wire them up as shown later in Fig.3.

SOFTWARE

The software for the Stopwatch is available on 3.5-inch disk from the Editorial office (see the *EPE PCB Service* page for details and cost), and via the *EPE* web site.

Preprogrammed PICs for the Stopwatch are available as discussed in *Shoptalk*.

COMPONENTS

CONTROL MODULE

See SHOP TALK page

Resistors

R1 to R6, R9, R10	10k (8 off)
R7	1k2
R8	220Ω

All resistors 0·25W 5% carbon film.

Potentiometer

VR1	5k (or 4k7) min. horiz. preset

Capacitors

C1, C2	15p ceramic (2 off)
C3, C4, C5	100n ceramic (3 off)

Semiconductors

TR1	BD681 (or equivalent, e.g. *npn* Darlington transistor TIP141 or TIP142)
IC1	PIC16C55 microcontroller, preprogrammed
IC2	78L05 +5V 100mA voltage regulator

Miscellaneous

S1 to S4, S6	push-to-make switch (5 off)
S5	min. s.p.s.t. toggle switch
S7	min. s.p.d.t. toggle switch
WD1	active buzzer, 9V to 12V
X1	3·2768MHz crystal
X2	u.h.f. receiver/decoder module, Maplin CR76H
X3	alphanumeric l.c.d. module, 16 × 1 or 16 × 2 (see text)
X4	u.h.f. transmitter module, Maplin CR72P (2 off)
X5	door minder module – see text (2 off)

Printed circuit board, available from the *EPE PCB Service*, code 246; connecting wire; solder, etc.

Approx. Cost Guidance Only £25 excl. radio control

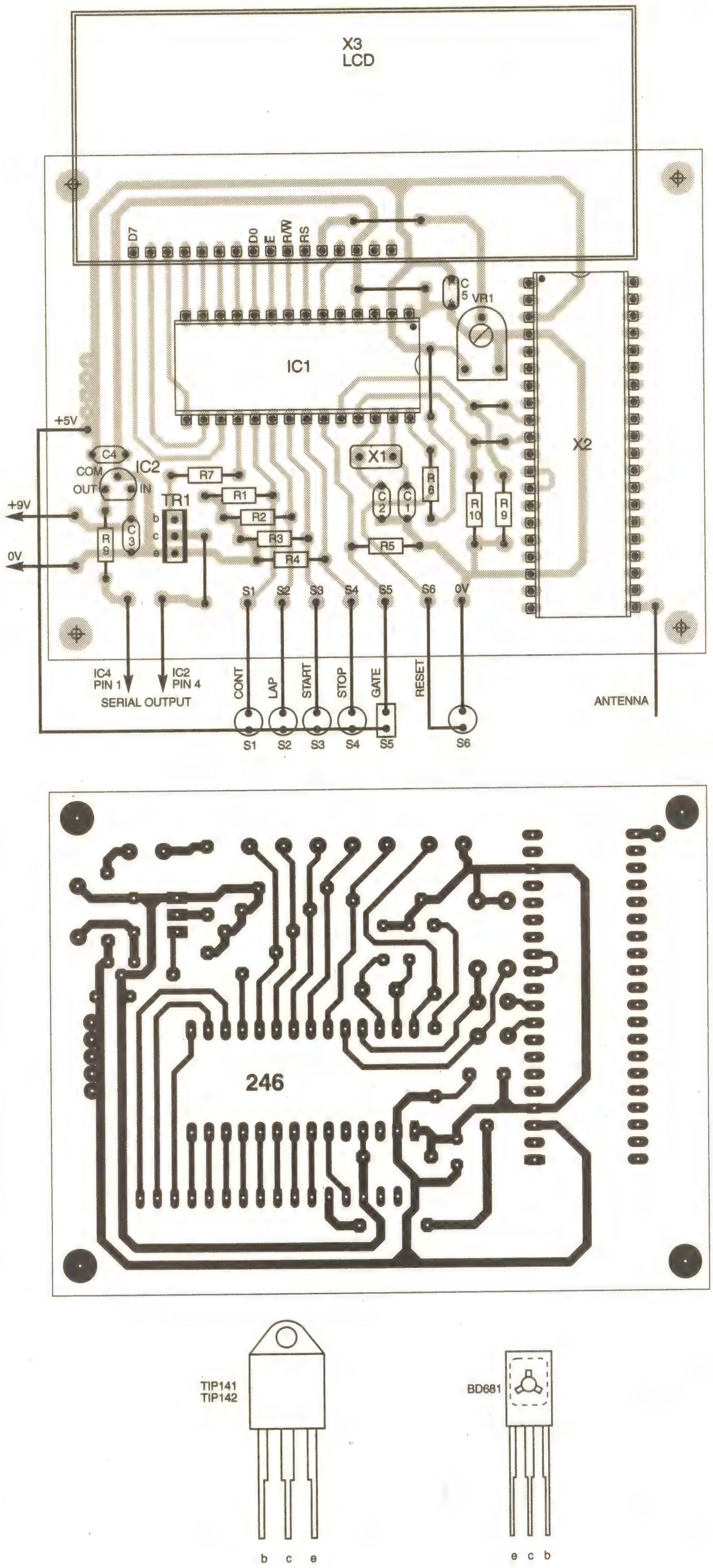


Fig.2. Printed circuit board component layout and full size copper foil track master pattern for the Stopwatch control module, plus pinouts for the TR1 alternatives.

CONSTRUCTION

Construction of the Stopwatch circuit is not very involved, but there are a few things to watch out for. The printed circuit board component layout and track details are shown in Fig.2. This board is available from the *EPE PCB Service*, code 246.

Put all of the resistors, transistor and power supply parts in first, followed by the sockets for the i.c.s., plus the two link wires between the PIC and receiver module positions.

If preferred, these two link wires could be replaced by toggle switches to isolate the effects of the optical gate transmissions when desired.

Do not at this stage put in the PIC or l.c.d. and receiver modules.

Now go around the board and look for 5V and 0V in all the right places and an open circuit in all the places that should not be connected yet (see Fig.1 and Fig.2). For example, the PIC socket should have pins 2 and 28 at +5V, pins 1, 4 and 19 to 25 at 0V, and the rest of the pin connections open circuit.

At the end of this checking you should know that there are probably no solder bridges to the power supply, that the pull-down resistors to pins 19 to 25 are working and that the master clear ($\overline{MCLR}$) is at +5V as it should be. You will also know that the power supply regulator IC2 is outputting the correct voltage of +5V.

After that, just insert the remaining components in any order that seems sensible, but leave the l.c.d. and the PIC until last.

The receiver has a couple of links to determine whether the outputs latch or are momentary when operated and you will need to connect its "link 2". This can be done on the module with a short piece of wire or else solder two pieces directly down to the Stopwatch module, where there is a link formed on the printed circuit board between pins 12 and 13 of the module's position.

Once all that is done, put in the PIC and the receiver module. The l.c.d. can be mounted directly on the board or via a 14-conductor ribbon cable – old computer cables work well. Just cut to length, strip and tin the conductors and solder them all in.

No particular case is recommended for the Stopwatch, and readers may use any plastic enclosure of their choice.

TESTING

Testing with microcontroller projects is generally of a "turn it on and see if its running" variety. So power it up and see if the l.c.d. starts up with a string of zeros separated by a colon and decimal point in the right places. Pressing the Start, Stop and Lap switches should have the desired effect.

Check for +5V at pin 3 of the receiver (X2) and ground at pin 4. Once the receiver has been taught the transmitter code (as described in its data sheet), you should find that pressing the transmitter's right-hand button should make pin 9 of the receiver change state and the left-hand button will do the same for pin 10.

The "door minder" units are tested as in the instructions that come with them. The toggle switch (S7) shown in Fig.3 will allow the buzzer (WD1) to sound when in position A, and allow the coded radio signal to be transmitted when in position B.

The transmitters are activated simply by connecting their power supply inputs as shown in Fig.3. Breaking the gate beam when S7 is in position B will cause transmission to start, lasting for as long as the beam remains broken.

To test this function, make sure the Gate switch (S5) is off, then break the gate beams in turn. The coded transmission signal should cause the Stopwatch to start and stop. Now switch S5 on and break the beam of one of the gates a few times, noting that the Stopwatch should alternately start and stop each time.

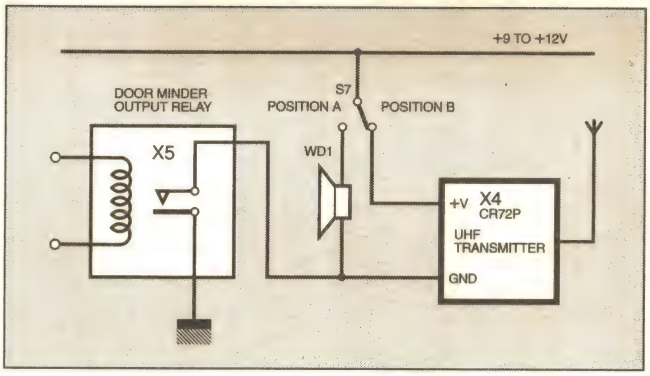
It is important to note that in this mode the Stopwatch has a time delay built in so that once the gate has been triggered there is a pause of about one second before the gate can be triggered again. This prevents the stopwatch being started and stopped by, say, a horse's four legs passing in front of the gate.

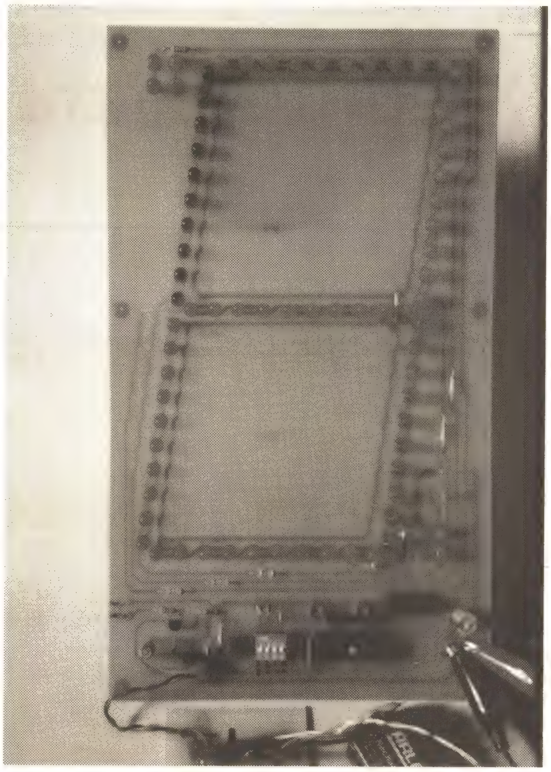
As mentioned, the software automatically tests the u.h.f. radio outputs to see if they are normally high (5V) or normally low (0V). It does this at reset so if you are using toggle switches to isolate the radio module outputs from pins 24 and 25 of the micro (the *start radio* and *stop radio* inputs), you should make sure the switches are closed before you reset the Stopwatch.

Hopefully all should be well, and your timer should be ready to stir up the action at all those tense sports events, especially after you have built Part Two next month ...

LARGE DIGIT DISPLAY

Next month, in Part Two, we describe the Large Digit Display that can be used with the Ginormous Stopwatch. Each digit board measures an astonishing 248mm × 142mm, and uses 78 l.e.d.s!





One digit of the Large Digit Display to be described next month.

LEGAL REQUIREMENTS

This design uses radio frequency modules that do not require a licence for use within the UK. However, in order to comply with Home Office regulation MPT1340, the transmitter and receiver enclosures must be clearly labelled as indicated below with lettering not less than 2mm in height:

MPT 1340
W.T.
LICENCE
EXEMPT

The *transmitter* antenna must be of an integral type. The Radio Communications Agency (RA) defines an integral antenna as "one which is designed to be connected permanently to the transmitter or receiver without the use of an external feeder". It is important, therefore, that the antenna is not accessible from the outside world and must not be removable.

In this instance, as long as the actual antenna wire is covered by a suitable sheath, such as a length of plastic wire-cladding and sealed at one end using a suitable adhesive, then it can be considered as integral. The *receiver* antenna can be integral or external as required.

New Technology Update

One area into which a vast amount of research effort is being placed is that of using copper in high speed integrated circuits, reports Ian Poole.

With technology moving at such a rapid pace it is necessary to have circuits that can reach higher frequencies and operate faster. In the radio frequency scene, higher frequencies are becoming more common place as use of the radio spectrum increases and higher frequencies must be used to accommodate the new services. This can be seen by the fact that the first cellular telephone services in the UK used frequencies around 900MHz, whereas some now use frequencies around 1800MHz.

However, this is only one small example of the increased use of the spectrum. To enable products to be successfully manufactured to meet the cost and performance requirements of the market place it is necessary to use integrated circuit technology. Accordingly the operating frequencies for i.c.s must increase.

Speeds in the digital side of the industry are also increasing rapidly to accommodate the increased processing power required by the more complicated programmes being written nowadays. Processors running at speeds of 400MHz are relatively common now, and it is likely that chips operating at 1GHz will be common place before too long.

However, to produce chips that run at the required frequencies or speeds is not easy. Feature sizes have been progressively reduced over the years. Now sub-micron dimensions are used in all new chips, and these advances alone have helped increase speeds by reducing the distances and the levels of spurious capacitance.

Reduced Resistance

The reduction in feature sizes is not the whole story. The resistance of the interconnections between different parts of the chip is now one of the major limitations preventing further increases in speed.

This arises from the fact that some degree of capacitance, even though very small, has to be charged up through the resistance resulting from the interconnections. This gives a delay resulting from the *RC* time constant and it is found this is now longer than the switching time of the transistors. Accordingly, any increases in the speed of the transistors themselves will be hidden by the propagation time of the signal along the interconnections.

Currently, aluminium is used to make any interconnections that are required. Although it has a relatively high resistance, when compared to other metals like copper and gold, aluminium is used because other metals diffuse into the semiconductor much more readily during the thermal stages of processing. Migration is also a problem and metals including gold and copper are particularly problematical.

Against these problems the use of copper gives a significant improvement in speed on its own, providing a claimed 30 per cent improvement. It would be possible to provide even greater levels of increase if the dielectric could be developed to reduce the levels of capacitance, but this is not an option at the moment as development problems are being encountered.

Ancient Remedy

To be able to use copper it has been necessary to develop a new process to enable it to be used without the possibility of diffusion or migration. This is achieved by laying the copper onto the silicon with an insulating layer around it. In many ways this new process emulates the structure of normal insulated wires used in commercial and domestic applications for interconnections.

The process is known as dual damascene, taking its name from an ancient pottery process. To achieve the insulation, trenches are first etched into the silicon using a plasma etch process. A layer of an insulator is then laid down onto the sides and bottom of the trench. The most common material for this is silicon nitride, but whatever the material it is only a few angstroms thick, although it is sufficiently robust to provide insulation at the relatively low voltages used.

The metal conductor is then laid down onto the surface of the whole wafer using an electroplating process. Excess material is then removed by polishing the wafer back to the silicon of the wafer. This is achieved using a lapping machine and a water based slurry. In order to completely isolate the metal interconnection a further layer of nitride insulator is then laid down onto the wafer surface.

In many integrated circuits five or more layers of interconnections may be required. However, it is normally only the first two or three layers that would use this process. In this way only those layers that are closest to the transistors and require the highest performance use the process.

Trench Tests

Tests have been carried out to test the yield and reliability of the basic idea. To achieve this a silicon-oxy-fluoride (SiOF) layer was laid onto a silicon surface using vapour deposition and then the trenches were formed.

The surface of the SiOF was exposed to ammonia and then copper was sputtered into the trenches. To prevent the copper diffusing into the SiOF, nitrogen doping was used around the edges of the trench.

The resistivity of the resulting copper interconnections was shown to be significantly lower than that of the aluminium ones normally used. In addition to this, none of the problems arising from the copper lifting from the surface were experienced once the process conditions had been correctly set. This was one of the major fears and had prevented a number of manufacturers from thinking the process was viable.

The overall result of the test was to give conclusive evidence that a significant reduction in propagation delay could be achieved. By adopting this process of using copper interconnects significant improvements in the overall performance of i.c.s have been shown to be possible.

Manufacturers

Now that it has been seen to be viable in terms of performance, the process needs to be utilised in the manufacture of real integrated circuits. Motorola and IBM are seen as the two world leaders in this field and they in turn have worked with other organisations including universities to bring the process to fruition. Now the process is being licensed to a number of other manufacturers.

There is a considerable amount of interest because the process has been shown to work, and the resulting i.c.s have been reliable. In addition to this the process does not require the use of any further mask steps or any new process equipment.

This will mean that manufacturers can incorporate the process without adding any costs to their capital investment. This is a considerable advantage in a market place that is particularly competitive and cost sensitive.

As a result of these advantages, the new process is now being incorporated into the plans of a number of manufacturers. Motorola are using it in high speed chips intended for use in servers and work stations.

Where cost is of paramount importance copper is only placed into the layers where it is actually required. In this way the bottlenecks that the new process introduces can be kept to a minimum. Despite this problem, it is likely to be used for many years to enable the required speeds to be achieved.

To this end, plans exist to use the process in new developments beyond the year 2002. In today's fast moving semiconductor manufacturing industry this represents a considerable amount of confidence in the new process.

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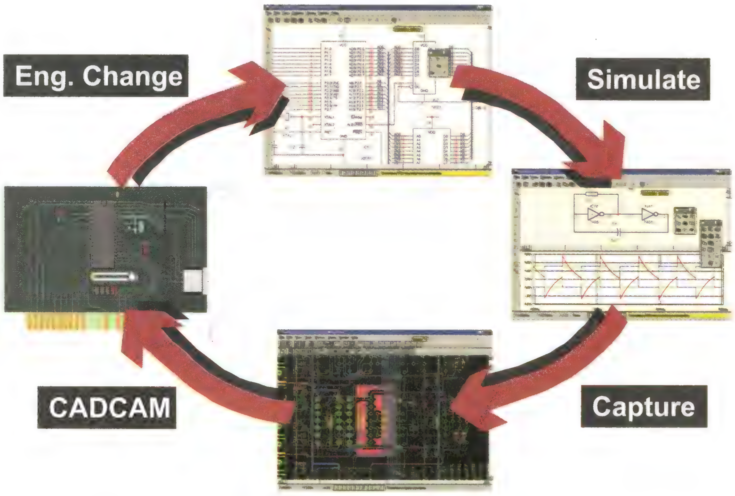
To create a schematic in Quickroute 4.0, simply click on the symbol browser and select and place symbols onto the design area. Use the 'intelligent' wires, power rails and data bus elements to quickly wire up your schematic and simulate the design as required. When completed, simply press a button to capture the schematic, a PCB rats nest will then appear (no messy netlists required!). Use the multi layer autorouter, and/or manual routing to complete your PCB together with copper fill, etc as required. Finally print your design, or create CADCAM files suitable for manufacture (we even include a Gerber viewer for checking).



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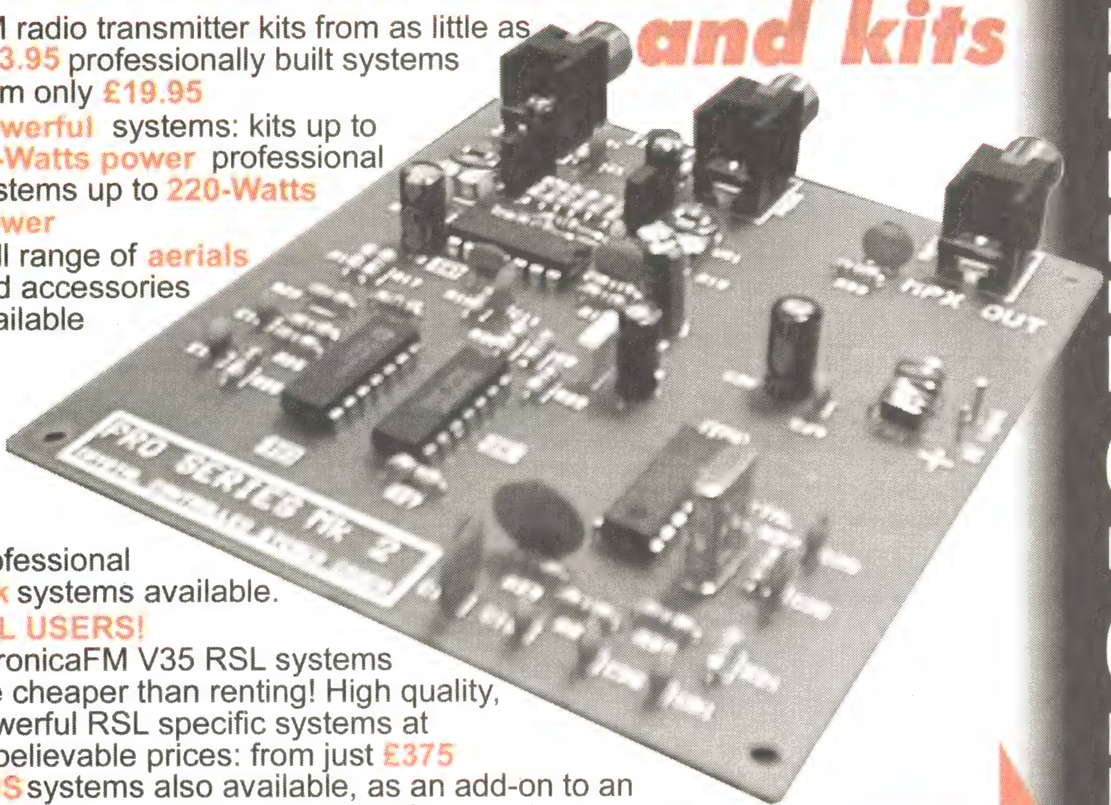

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News . . .

A roundup of the latest Everyday News from the world of electronics

OFTEL AND BT AT ODDS OVER PHONE LINES

Who should set standards, national agencies or international industries? Barry Fox highlights the question.

OFTEL wants to kickstart the delivery of wide bandwidth data and video to homes and small offices, using the new Asymmetric Digital Subscriber Loop technology that works with ordinary copper phone wires. This makes the UK a world leader but puts Oftel on a collision course with BT which wants to do the same thing but differently.

In its report published in early July (**www.oftel.gov.uk**, Access to Bandwidth: Proposals for Action), Oftel applauds the consumer trials of ADSL which BT has carried out in homes near its research labs in Martlesham and in North London, but wants to stop BT creating a monopoly by setting the technical standard for everyone else.

BT OPPOSES OFTEL

BT is radically opposed to Oftel's plan to let competitors use any technology that does not cause interference. BT warns that Oftel may not be able to set up the necessary spectral management scheme in time for its promised service launch by July 2001.

"It raises significant operational, technical and security issues", says BT. "We will co-operate with Oftel but press on with our own bold plans."

To drive the message home, BT is spending £5 billion on upgrading its network and pre-empted Oftel by contracting Fujitsu and Alcatel to equip 400 exchanges, serving 6 million homes, by Spring 2000.

The US government relaxed its control on the phone system in 1996, leaving rival operators free to use whatever technology they like, and without any overall spectral management plan. Peter Walker, Oftel's Director of Technology, believes this will backfire and as more services come on stream they will start to interfere with each other.

"You can't have a complete free for all", says Walker. "That is why the rest of the world is watching and waiting to see what happens in the UK."

POTS AND ADSL

Conventional twisted pair copper telephone wires are designed to carry POTS, or plain old telephone services, with analogue speech frequencies up to 4kHz. PC and fax modems convert digital code into switched analogue tones which fit into this band. The maximum data rate is 56Kbps. The same wires can carry digital voltage pulses streaming at 144Kbps, for ISDN services, but only over a few kilometres. This occupies a bandwidth up to 40kHz.

ADSL splits a higher rate digital signal into many separate streams and slots them into many hundreds of very narrow frequency bands which sit above the POTS signal. A standard set by the International Telecommunications Union (G.992.1) provides downstream data rates of up to 8Mbps, and an upstream return path of up to 800Kbps, depending on how far the subscriber is from the exchange. In practice, the downstream rate is limited to around 2Mbps, because this is reliable over several kilometres and sufficient for MPEG digital video of VHS quality for video conferencing or video-on-demand entertainment. The slower, asymmetric, return path is adequate for data transmission, still pictures or low quality video.

Each subscriber needs a modem in the home and another at the telephone exchange dedicated to the subscriber's line, each costing several hundred pounds.

Variants of ADSL, usually known as Lite (ITU G.992.2), cut costs by using simpler circuitry and no splitter to separate the POTS and DSL signals. This reduces downstream data rates to between 750Kbps and 1·5Mbps, and return rates of 128Kpbs. Splitterless Lite modems can be slotted into a PC to increase the speed of Internet access. In the US, where Lite Internet access at 1·5Mbps is on offer in major cities such as New York and Washington for $50 a month, Compaq builds DSL modems into its top end PCs in the US. Texas Instruments has now announced a Lite modem chip for under $10.

Future systems, High and Very High data rate DSL, will use frequencies up to 300MHz to give data rates up to 50Mbps.

OFTEL'S OPINION

Oftel warns that if different services use different systems, operating at different frequencies, there is real risk of crosstalk interference between cables that run in the same underground ducts.

Oftel has, however, rejected Option 4, which would reduce interference risks by letting BT set a standard, and insist that all its competitors adopt it if they want to share BT's lines. Instead Oftel recommends Option 2, which "unbundles" BT's network by letting competitors upgrade and use whatever technology they like on BT's lines, as long as it meets interference criteria to be laid down by Oftel.

Oftel invites comments on its report by the end of September and will then work with the Radiocommunications Agency on a Spectral Management Plan. BT's competitors will be free to use BT lines by July 2001.

Director General David Edmonds says "I am confident that competing operators can have direct access to BT's network by 1 July 2001. The UK will then have the best communications network in the world and be the best place to do business electronically by 2002".

International market analyst Datamonitor predicts that by 2004 one fifth of all business will be using DSL lines to access the Internet.

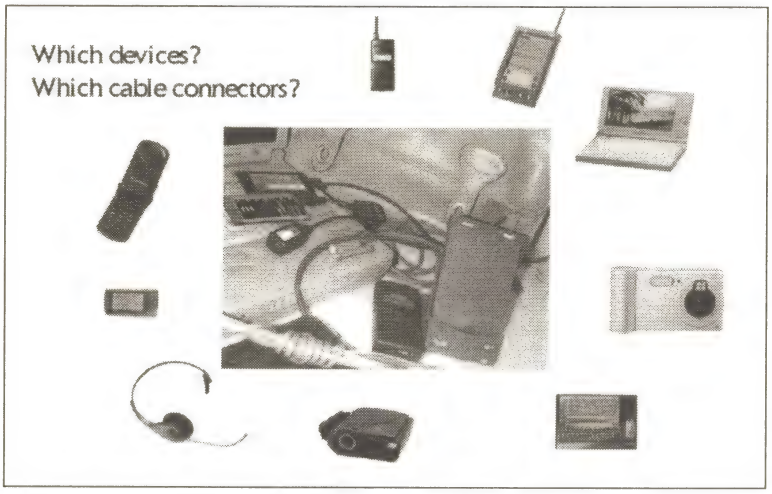
*WRITE*LIGHT

*Write*LIGHT is a novel new ball-point pen that enables the user to read and write in the dark. It has two l.e.d.s built around the writing tip. These emit a powerful milky-green light that shines onto the writing/reading area. We are told that the light does not impair night vision (although amateur astronomers should double-check with the suppliers on this point), and that it does not cast a shadow. The pen is also water resistant.

Battery life is said to be up to 15 hours of constant use – longer, of course, for intermittent use. The suggested retail price is £9.99 and batteries are included.

The *Write*LIGHT pen is marketed by Innoventions International Ltd., Dept EPE, 71 Watts Road, Studley, Warks B80 7PU. Tel: 01527 857097. Fax: 01527 853771. E-mail: innoventions@lineone.net.

BLUETOOTH



ABOUT a year ago, industry leaders Ericsson, IBM, Intel, Nokia and Toshiba unveiled their vision of wireless connectivity for personal and business mobile devices – Bluetooth. Since then more than 500 companies have joined the Bluetooth Special Interest Group and have produced the Bluetooth Specification.

Bluetooth will enable users to connect a range of computing and telecommunications devices easily and simply, without the need to buy, carry or connect cables. Bluetooth-enabled products are expected to include mobile computers, handheld PCs, digital cellular mobile phones, and peripherals such as cameras, printers, projectors, PC Cards and hands-free head-sets. Network access points will also be developed to facilitate wireless connection to LANs and WANs (Local/Wide Area Networks). Such-equipped devices will be designed to operate globally, regardless of where they were purchased.

The Bluetooth technology aims to make these innovations possible through small short-range radio links that operate world-wide in the 2.45GHz band and to link devices within a 10-metre radius. Simultaneous voice and data transmission is supported.

The public release of the final Bluetooth specification version 1.0 is scheduled for later this year. Products will become available in the first half of year 2000. Adoption of the technology is expected to be widespread throughout the computer and telecommunications industry.

For more information, access **www.bluetooth.com**. The illustration was kindly supplied by Toshiba.

ON-LINE FOR MOVIE BUFFS

By Barry Fox

THE British Film Institute claims it is first in the world to offer the public on-line access to film and television archive material. Instead of having to wait weeks to book a private viewing of a taped copy, film buffs and researchers can now drop into centres run by the BFI to search and view landmark movies and TV programmes, stills, original scripts and historical information.

Movie material from the BFI's archives is being digitised as MPEG-1 code, streaming at 1·7Mbits/s. This is decoded by software running under Windows NT on 300MHz Celeron PCs. Quality is excellent even when displayed on the PC's full screen area.

Some material is ideal for split screen windowing. When Alfred Hitchcock made *Blackmail* in 1929 he started to shoot a silent movie with titles and then re-made it with the then-new synchronised sound system. The BFI has digitised both versions for Online, along with their scripts. So a researcher can play both at the same time, while following the script to see how the actors handled their parts and lines.

The BFI currently holds 350,000 films and seven million stills in its archive, and has so far digitised only a few dozen classic movies (including the *Four Feathers*, *Red Shoes* and *Black Narcissus*) and TV programmes (*Cathy Come Home*, the *War Game*, *Blind Date*, *Weekend World* and the *South Bank Show*). Because of copyright restrictions these cannot be distributed on the open Internet but the BFI Online Intranet is being piped by 2Mbit/s link to terminals at the National Film Theatre on the South Bank and the Broadway Media Centre in Nottingham. Northern Ireland gets a link next year.

Visitors to the BFI's library in Central London must pay £6 for a library day ticket, but NFT access is free.

BFI Director John Woodward says one old lady was quick to exploit the NFT's terminal. She settled down with her knitting to watch the first ever episode of TV series *Upstairs Downstairs*.

Wireless For The Blind

THE annual fund-raising event in aid of the British Wireless for the Blind Fund, *Transmission 99*, will be held this year on the weekend of 9 and 10 October. As usual, it will involve radio amateurs from all over the world who want to help blind people.

BWBF is appealing to all amateur radio clubs, their members and individuals to take part in *Transmission 99*. All they need to do is sponsor every contact made on air during the period of the event. New, specially designed QSL cards are available, free of charge, for all those taking part.

Margaret Grainger, Chief Executive of the Fund hopes more clubs and individuals take part. "For those who cannot see, radio provides far more than entertainment, it is a vital means of keeping in touch with the world. Over the years we have supplied more than three-quarters of a million sets to blind people."

Anyone wanting to join in the fun of *Transmission 99* should contact BWBF at Gabriel House, 34 New Road, Chatham, Kent ME4 4QR. Tel: 01634 832501. Fax: 01634 817485. E-mail: Margaret@blind.org.uk.

Racetrack Timing

THE letter from Frank Korver in *Readout* Sep '99 prompted an RAC representative, Mr Bloodworth, to advise us that UK company HS Sports Ltd provide computerised timing systems based on rechargeable coded transponders on each car. We obtained their brochure.

The systems are basically designed for use with Karts (Go-Karts some of us remember them as – and drove them!), and are used at Karting centres around the globe. There are a number of variants but all of them have one thing in common, they can simultaneously monitor many Karts at once, up to 300 with one system, and can cope with multiple cars crossing the line at one time.

You may recall that we commented in *Readout* that James Humphris' *Wireless Monitoring System* of Feb '99 was unable to separate simultaneous transmissions from two or more sources. The *Stopwatch* design published in this November issue can monitor two sources.

Frank Korver is involved in Stock Car racing and said that these can pass by at 100km/hr, a speed which should be no problem for the Kart timing system to keep track of, being capable of typically handling speeds of 70mph for one system, to 100mph for another (112-160km/hr).

The quoted prices of the systems range from £3,950 (10 transponders) to over £40,000 (300 transponders).

For more information contact HS Sports Ltd., Dept EPE, Unit 5, Radnor Park Industrial Estate, Congleton, Cheshire CW12 4XN. Tel: 01260 275708. Fax: 01260 278352. They also supply other systems, including one for F1 cars.

E-mail: hssl@congleton.onyxnet.co.uk.

BLUMLEIN BOOK

The Inventor of Stereo – The Life and Works of Alan Dower Blumlein

By Robert Charles Alexander.

Regular *EPE* readers will know something of Alan Dower Blumlein from our articles back in September '91 and June '99. This excellent well researched book by Rob Alexander should put Blumlein's name firmly up there with Edison and Faraday.

It is not always an easy read because of all the technical information it presents but the book does describe in some depth Blumlein's 1931 invention of binaural recording (now known as stereo), the development of the 405 line television system in the mid 1930's – which was used more or less unaltered in specification until the eighties – and the development of the H2S radar system during the war. It was while testing airborn radar that Blumlein lost his life, along with several other members of the development team from EMI, in a tragic plane crash. The reasons behind the crash are also explained.

This virtually unknown UK inventor lived for just 38 years and instigated 128 patents in that time. Fascinating man, fascinating inventions, fascinating story behind the 30 year wait for a biography. We recommend you read it – our congratulations to Rob Alexander.

The book costs £29.99 in hardback form and is now available through the *EPE Direct Book Service*, order code NE32, see page 849 for ordering details.

There are also several complimentary websites set up to coincide with the book launch. The main site includes unique information which could not be included in the book, the 1930s binaural films and audio recordings, and all 128 patents published in full for the first time: **www.gedas.co.uk/blumlein**.

PROSPICE LITE

LABCENTER Electronics have upgraded their shareware CAD software, PROTEUS Lite, to version 4.7, and also added a shareware version of their circuit simulator, PROSPICE.

PROSPICE Lite is aimed squarely at the educational market and uses animation rather than traditional graphs or virtual instruments to show the operation of the circuit. In addition, voltage can be indicated by the colour of wires, and current by the presence and direction of arrows.

The simulator is supplied with a set of over 60 samples which cover topics from basic electricity through to simple electronics. The sample circuits are provided as a freeware educational resource; registration of the software enables users to create their own circuits from a schematic library of over 6000 real-world components. Comprehensive coverage of 7400 and 4000 logic series is included.

Uniquely, it is also possible to create your own animated models with the package so that animated circuits are not restricted to a hard coded set of devices. Supplied animated parts include bulbs, switches, buttons, pots, motors, fuses, l.e.d.s, 7-segment displays, and more.

Registration of ISIS Lite (the schematic capture module) costs £20 and registration of the simulator costs a further £10.

Further information and downloads are available from Labcenter's website: www.labcenter.co.uk. The company can also be contacted at Dept EPE, 53-55 Main Street, Grassington, North Yorks BD23 5AA. Tel: 01756 753440. Fax: 01756 752857.

DX-BANDS

JULY saw the launch of a comprehensive Amateur Radio Portal on the Web: **dxbands.com** is designed for amateur radio enthusiasts around the world and gives them the opportunity to find up-to-the-moment amateur radio news, details, dx-peditions, contests and page-upon-page of ham radio links.

The site includes a unique "dx-diary" which, month by month, lists dx-peditions large and small world-wide. It itemises the dates of each event, together with details of the QSL manager, and other information. Updated each day with the latest amateur radio news, this site is expected to become an important online resource.

Browse **http://www.dxbands.com** (or E-mail news@dxbands.com) and find out for yourself.

Voice Control

NATIONAL Semiconductor Corporation and Lernout & Hauspie Speech Products N.V. have announced they have a signed an agreement to support and accelerate advanced speech processing technology in the emerging information appliance market.

The two companies will jointly develop new uses and applications for L&H's automatic speech recognition (ASR), text-to-speech (TTS) and speech compression technologies. They plan to enable voice-activated computing on a variety of next-generation consumer electronics devices, such as personal Internet access devices like National's WebPAD, automobile PCs, handheld devices and other emerging information appliances.

"The voice is the ideal human interface, and soon it will no longer be necessary for us to modify our natural behaviours in order to communicate with machines," said Brian Halla, CEO and Chairman of National Semiconductor. "Children born today might never need to use a keyboard in their lives."

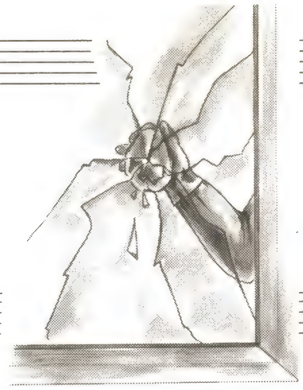
More information can be found via **www.national.com** and **www.lhs.com**.

Mobiles Help Jams

MORE than 11500 calls for traffic and travel information are made every day using the mobile phone network, advises a press release from the RAC. This figure, totalling a massive 4·2 million calls every year, is set to more than double over the next twelve months.

The revenue that such a quantity of calls from motorists who wish to plan their journeys and make the most of dynamic traffic information as they travel must be astronomical. Isn't it time that users benefitted from this high system usage by seeing lower call prices, which typically cost between 39p and 60p a minute? Shouldn't the RAC, and the AA, be campaigning for call charge reductions when accessing traffic information that could potentially help so many motorists?

Constructional Project



VIBRALARM

TERRY de VAUX-BALBIRNIE

A multi-purpose vibration-triggered alarm with remarkable sensitivity.

THIS circuit will sound a loud warning when a sensor is subjected to shock or vibration. One application would be to attach the sensor to a window. If an attempt was made to enter the house by breaking the glass, the alarm would be triggered.

Readers will no doubt find other possible uses, such as for protecting personal belongings, perhaps. Note, however, that simply moving the sensor will not operate it.

The sensitivity of the circuit is adjustable and can be set to suit the application. To get an idea of the sensitivity, with the prototype sensor attached to a wooden table, putting a coffee cup down about 1m (3ft) away triggered it.

VIBRALARM OVERVIEW

The Vibralarm comprises two parts. The first is the sensor itself mounted in a small plastic case. The main unit is housed in a larger plastic case (see photographs). The two sections are interconnected using a short piece of light-duty screened wire.

Inside the main unit is the circuit panel, the battery pack and a loud "yelping" car-type alarm siren. On top, there is a key-operated switch which may be used to switch the unit off or cancel operation before the natural time-out period. Of course, an ordinary switch could be used with a corresponding reduction in security.

The operating time is adjustable from about one second (which will be found useful for testing) to two minutes. This could be easily extended if required.

The circuit requires about 250µA on standby. While actually operating, it draws a current which depends on the type of sounder used (in the prototype it was 150mA). The prototype unit was powered using a pack of eight AA-size alkaline cells. In normal use these will last for up to a year.

BI-MORPH ELEMENT

The sensor consists of a bi-morph (2-layer) element, which is a strip of piezo-electric material 15mm long, 1·5mm wide and 0·6mm thick. Its simplified operation is illustrated in Fig.1a, which shows an ordinary wooden ruler. Normally, this is not under any stress.

However, if it is bent as shown in Fig.1b, the lower surface will now be in compression (the distance between the molecules slightly reduced) and the upper one under tension (the distance between the molecules increased).

When a bi-morph element is bent, opposite charges are developed on the surfaces which are under compression and tension due to the piezo-electric effect. This means that a voltage difference appears between them. A current would flow if there was a conducting path between the surfaces but the charges would soon neutralise so this would occur only briefly.

WHAT'S THE DIFFERENCE?

With the piezo ceramic material used here, the voltage difference is significant even with a small amount of bending. When the bi-morph element is subjected to shock, the upper and lower surfaces alternate briefly between compression and tension and the polarity of the voltage will keep changing. In other words, an alternating voltage is produced at a frequency equal to that of the vibration.

Bi-morphs were once used in the crystal-type of record pick-up but, although still sometimes used, they are not seen much now. In these pick-ups, the strip is vibrated by the stylus running in the groove on the surface of the record.

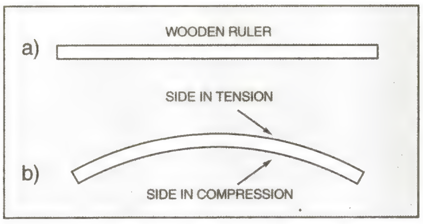


Fig.1. Simplified analogy using a wooden ruler to demonstrate the operation of the bi-morph element.

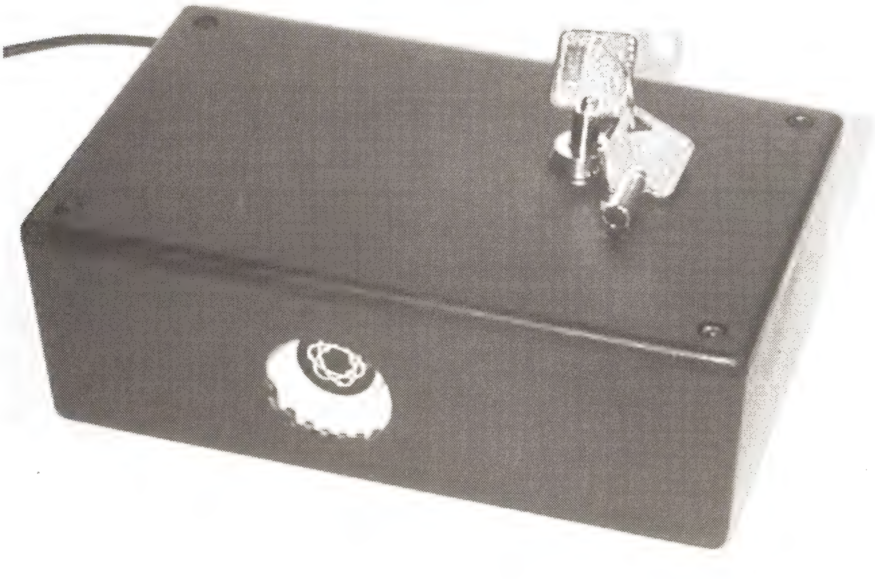
An a.c. output is therefore obtained proportional to the frequency of the sound (assuming the record is turning at the correct speed) and roughly proportional to its amplitude. The signal is then amplified and fed to a loudspeaker.

CIRCUIT DESCRIPTION

The full circuit diagram for the Vibralarm is shown in Fig.2. The bi-morph element is labelled X1. The nominal 12V battery supply is applied to the circuit via key-operated (or other) switch S1, and diode D3. The diode prevents possible damage if the supply were to be connected in the wrong way since it would fail to conduct and nothing would happen.

Any voltage appearing across the bi-morph element is applied to the inverting input (pin 2) of operation amplifier (op.amp), IC1. The network consisting of capacitor C1 and resistor R2 is also connected between this point and the 0V line. These components help to prevent high-frequency oscillation and give a damping effect for the bi-morph element.

Since the impedance of the bi-morph



is very high, the value of R2 must accordingly be extremely high or it would cause excessive damping. The values shown worked well. However, this could be the subject of experiment once the project has been constructed.

The op.amp non-inverting input (pin 3) is connected to the sliding contact (wiper) of preset potentiometer VR1. Its track (outer) connections are connected across Zener diode D1, which operates in conjunction with series resistor R1 to provide a fixed-voltage supply. The voltage appearing at IC1 pin 3 may therefore be adjusted between zero and the Zener breakdown voltage.

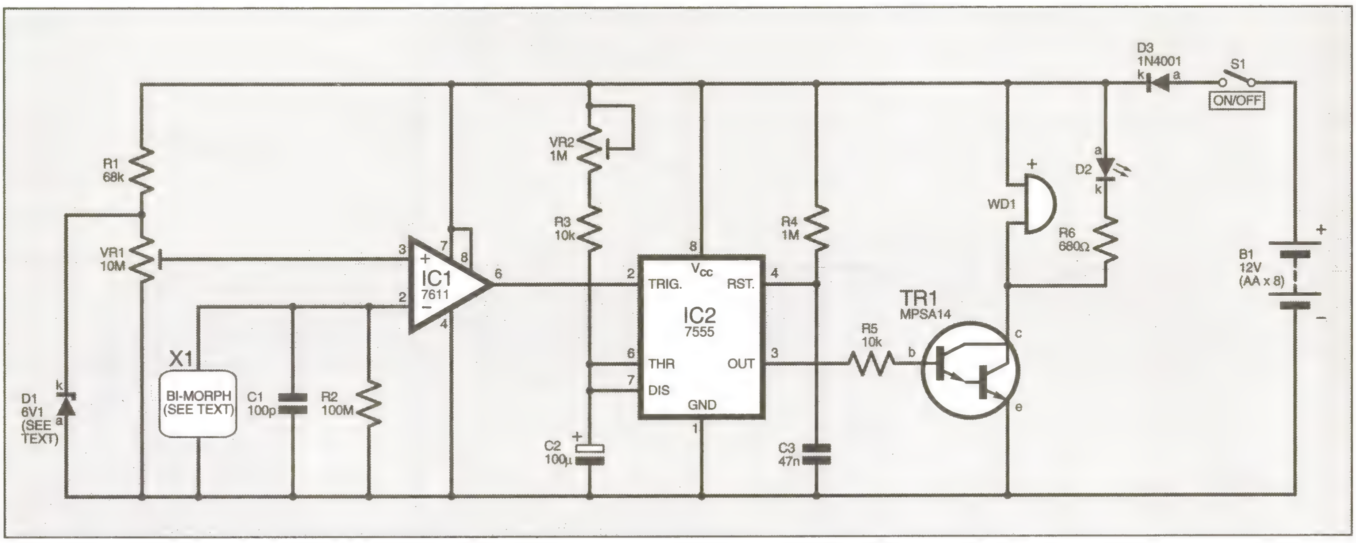


Fig.2. Complete circuit diagram for the vibration-triggered Vibralarm.

ZENER VOLTAGE

It is necessary to provide a stable voltage here because if it was derived from the supply direct, it would fall as the battery aged. Since the voltage appearing across the bi-morph element is independent of the supply voltage, the operating characteristics of the circuit would change as the batteries ran down. The exact value of the Zener voltage is not important but it should be close to the range of specified values.

It will be noted that the value of R1 is relatively high. With a supply of 12V it allows less than 90µA to flow through the Zener diode and this will fall as the battery ages. The current diverted via VR1 is negligible. Using such a small current here reduces the requirement of the circuit as a whole. When using the specified Zener diode (which has been designed for low-current, low-power and low noise applications) there will be no problems.

However, if using a different type of Zener, it might not stabilise and it may be necessary to increase the current. Readers using a different Zener will need to check the stabilisation and reduce the value of R1 if necessary. This procedure is explained at the setting-up stage.

NO VIBRATION

Imagine that preset VR1 is adjusted so that 1V appears at IC1 pin 3. In the absence of any vibration of the bi-morph, there will be no voltage across it and the voltage at the non-inverting input (pin 3) will exceed that at the inverting one (pin 2). The output, pin 6, will therefore be high (close to the positive supply voltage) and when applied to timer IC2 trigger input (pin 2) there will be no further effect. This is because a low state is needed to trigger this type of device.

IN SHOCK

When the bi-morph element X1 is subjected to shock, an alternating voltage appears across it having a peak-to-peak value relative to the impact strength. Within limits, the negative excursions have no effect. However, they can cause the inverting input to swing below the voltage of the 0V rail and this could damage the i.c. if high enough. There were no problems with the prototype, though, even under heavy shock.

Depending on the adjustment of VR1, the positive peaks will exceed the voltage at IC1 pin 3. Each time this happens, the op.amp output (pin 6) will go low instantaneously. The first peak arriving at IC2 pin 2 will trigger it and a timing cycle will begin. Further trigger pulses applied during this period will have no effect. However, any arriving afterwards will start the timing once again.

While timing, IC2 output pin 3 goes high and allows current to flow into the base of Darlington transistor TR1, via current-limiting resistor R5. Sounder WD1 then operates due to current flowing in the collector circuit.

Light-emitting diode D2 is also turned on at this time, with its current limited to about 15mA by resistor R6. The l.e.d. will be useful to check the circuit and adjust the time-out period before the sounder is connected.

SENSITIVITY

The sensitivity of the circuit may be adjusted at the end by means of VR1. With this set to a little above zero volts, the circuit will be triggered with a relatively small amount of vibration. However, if it is adjusted to a higher value, an increasingly high output from the bi-morph is needed to trigger it.

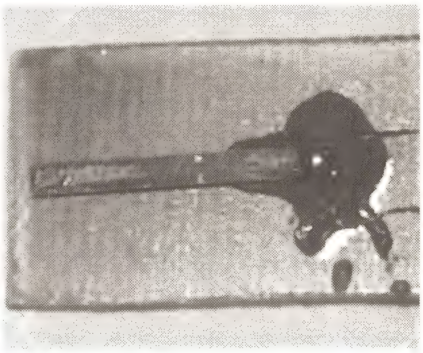
The timing period depends on the value of capacitor C2, resistor R3 and preset VR2. With the values specified, this will be about one second (with VR1 at minimum) and two minutes (when at maximum). If the timing needs to be extended, the easiest way would be to increase the value of C2 in proportion.

When the supply is connected, capacitor C3 maintains IC2's reset input (pin 4) in a low state for a short time until the capacitor has charged sufficiently through R4, so disabling the i.c. from responding to any trigger pulses. After that, pin 4 goes high and the device is enabled. This prevents any tendency for the circuit to self-trigger on powering-up.

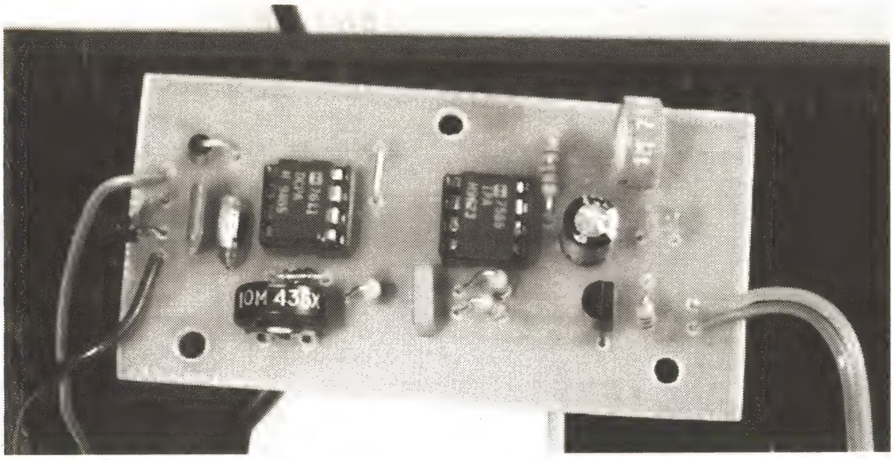
Darlington transistor TR1 could operate a sounder of up to 500mA rating but this would place an unnecessary load on the battery. Very loud devices are available with a current requirement much smaller than this (say 150mA) and one of these was used in the prototype.

CONSTRUCTION

On no account experiment by bending the bi-morph element with the fingers. Anything more than a minute movement is likely to destroy it. Also, take extreme care when handling the end wires because they are easily broken off.



Close-up of the bi-morph element mounted on its p.c.b.



Layout of components on the finished printed circuit board.

All the components, apart from the sounder, on-off switch, battery pack and bi-morph element are mounted on the printed circuit board (p.c.b.) whose component layout and full-size copper foil master are shown in Fig.3. This board is available from the *EPE PCB Service*, code 230.

Supplied attached to the main board is a smaller section on which the sensor is to be mounted separately. Begin construction by carefully separating the two p.c.b. sections, using a small hacksaw. Then drill the three marked mounting holes in the main board, and a mounting hole in a suitable place on the small board.

Referring to the main board, solder the link wire in position and follow with the i.c. sockets (but do not insert the i.c.s yet) all resistors (including the presets) and capacitors (except C2). Next mount diode D3, Zener diode D1, l.e.d. D2 and capacitor C2, taking care to solder these components the correct way round.

Referring to the wiring diagram in Fig.4, connect up the power supply. It will be kinder on the ears if you do not connect the sounder yet, but when you do, connect it via a piece of 2A screw terminal block to prevent the WD1 wires from short-circuiting.

Adjust VR1 fully anti-clockwise, then slightly clockwise (as viewed from the bottom edge of the p.c.b.) and VR2 fully clockwise (as viewed from the right-hand edge of the p.c.b.) for minimum timing.

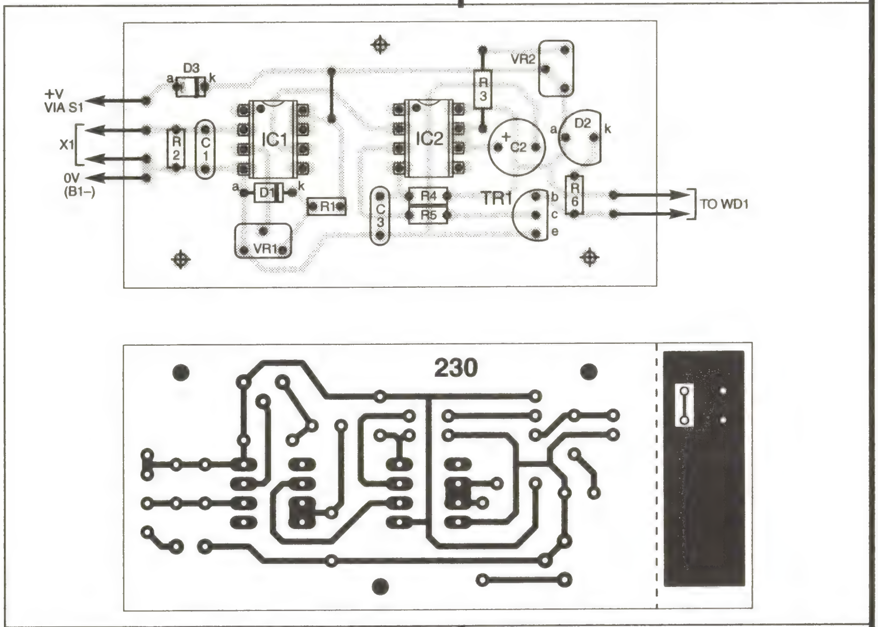


Fig.3. Vibralarm printed circuit board component layout, foil master and sensor board master.

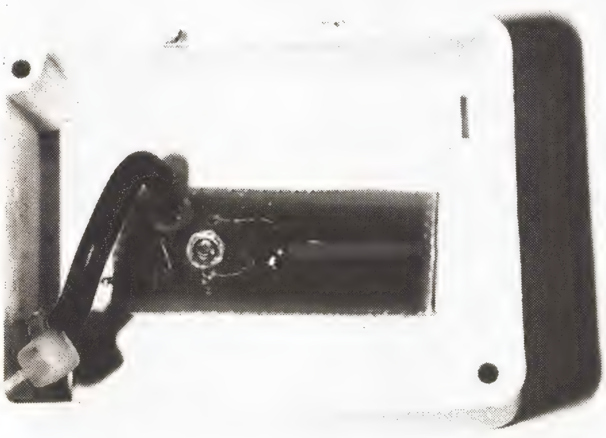
SENSOR UNIT

Solder the bi-morph to the small board and reinforce its physical stability by using a little quick-setting epoxy resin adhesive. The blob of adhesive should be thick enough to allow the other end of the bi-morph to remain clear of the board by a millimetre or so.

This will allow it to bend slightly when the mounting board is subjected to shock. If necessary, use a piece of thin cardboard underneath the free end to hold it in position until the adhesive has thoroughly hardened.

Decide on the length of wire needed between the sensor and the main unit. Pieces up to five metres long were tested and worked well. However, very long runs will introduce problems of interference pick-up and poor sensitivity.

Use light-duty single (mono) screened wire (such as microphone cable).



The bi-morph board installed in a small plastic case.

COMPONENTS

See SHOP TALK page

Resistors

R1	68k
R2	100M cermet film
R3, R5	10k (2 off)
R4	1M
R6	680Ω

All 0·25W 5% carbon film, except R2.

Potentiometers

VR1	10M sub min. preset, vertical
VR2	1M sub min. preset, vertical

Capacitors

C1	100p polystyrene.
C2	100μ radial elect. 16V
C3	47n metallised polyester, 5mm pin spacing

Semiconductors

D1	5V9 to 6V2 400mW Zener diode, Philips PLVA459A or PLVA462A (see text)
D2	red l.e.d., 3mm
D3	1N4001 50V 1A rectifier diode
TR1	MPSA14 *npn* Darlington transistor
IC1	7611 micropower op.amp
IC2	7555IPA low power timer

Miscellaneous

X1	bi-morph element
WD1	min. alarm sounder, 12V, 150mA (110dB at 1m output)
S1	s.p.s.t. switch (toggle or key-operated)
B1	alkaline AA-size cell (8 off), with holder and connector

Printed circuit board, available from the *EPE PCB Service* code 230; 8-pin d.i.l. socket (2 off); 2A terminal block; plastic case, 158mm×95mm×54mm (external) for main unit; plastic case, 50mm×37mm×24mm (external) for sensor; light-duty single screened wire; small clamps or cable ties (2 off); connecting wire; solder, etc.

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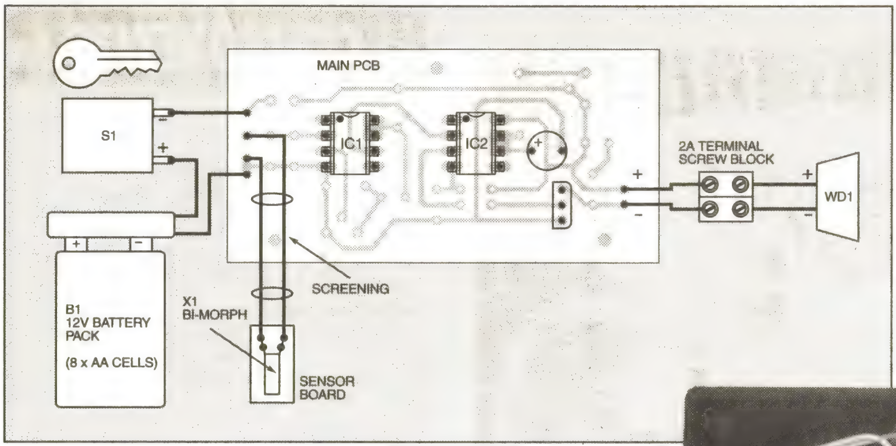


Fig.4. Interwiring between the circuit board and the off–board components, including the bi-morph board.

Ordinary wire is not satisfactory because it allows the pick-up of random signals, including a.c. mains "hum". This could cause false triggering.

A small plastic box is used to house the sensor, and it is worth mounting the sensor in this now before moving on further. Mark the mounting hole on the base and drill this through. Note that the bolt which will be used to attach it will need to have a countersunk head. This will allow the bottom of the box to make good contact with the surface on which it will be used.

Drill a hole in one side of the case for the connecting cable. Pass this through and apply a small clamp or tight cable tie a short distance from the end (see photograph). Allow enough cable to reach the sensor pads plus a little slack. Pull on the cable to make sure it is secure and tighten the tie if necessary.

Solder the cable wires to the pads on the sensor p.c.b. with the screening connected to the large "land" area. Separate the joints to prevent short-circuits and secure them in place using a little quick-setting epoxy-resin adhesive.

Attach the sensor board to the bottom of the box using a small nut and bolt with a short plastic spacer.

VOLTAGE STABILITY

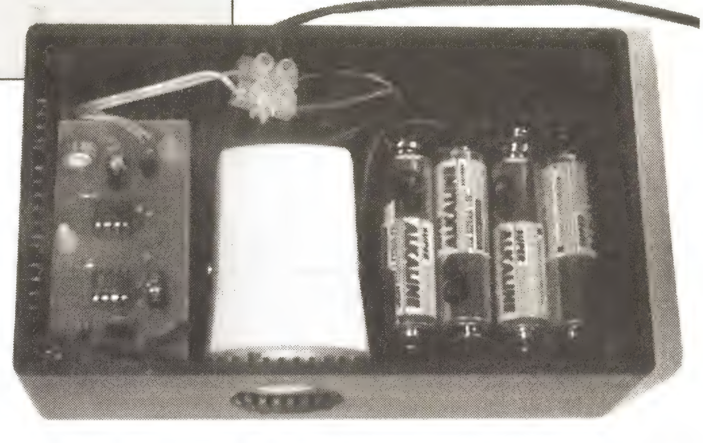
As stated earlier, for any Zener diode other than the specified unit, it will be necessary to check the voltage stability. It will be convenient to do this work before the i.c.s are inserted into their sockets.

You will need a digital voltmeter (this will generally have an input impedance of 10MΩ or more, which will be satisfactory). You will also need two sets of batteries – one new and the other run down so that the terminal voltage is about 9V or 10V. Of course, you could also use a suitable bench power supply unit.

With the new set of batteries installed, switch on. Apply the meter probes to the outer tags of VR1 and note the voltage. This should be close to the stated Zener breakdown voltage. Now use the run-down batteries or a 9V supply from the PSU. Note the meter reading once again.

The second voltage reading should be the same or only slightly lower than the first – less than 0·05V difference. The stabilisation aspect is not very critical and the circuit should work well even with a difference of 0·1V.

However, if it is much more than this, reduce the value of R1 until the criterion above is met. It is thought that a value as low as 33kΩ would be acceptable (about 180µA at 12V) but it would increase the current requirement of the circuit to about 350µA and this would have an effect on battery life.



Layout of components in the main unit. Note the siren sound exit hole, 2-way terminal block and battery holder.

FINAL TESTS

It would now be a good idea to test the circuit as a whole before mounting the main p.c.b. in its box. Referring to Fig.4, connect the sensor cable wires temporarily to the board as shown. Still leave the sounder unconnected. Insert the i.c.s into their sockets. It is possible to damage these devices with static charge which might exist on your body so, as a precaution, touch something which is earthed (such as a water tap) immediately before handling the pins.

Attach the sensor unit to the work surface temporarily using Blu-Tack. Insert the (good) cells into their holder and switch on. The l.e.d. should remain off.

Drop a pen on the table – the circuit should trigger and the l.e.d. come on for one second or so. If this does not work, make the circuit more sensitive by adjusting VR1 slightly anti-clockwise (as viewed from the lower edge of the p.c.b.). Note, however, that if this is overdone, the circuit may remain triggered. Do not move the bi-morph element by hand or subject it to violent shock.

The current requirement of the circuit rises above the normal value when set to a short time period – about 1mA in the prototype. For this reason, when testing is complete, adjust VR2 to about mid-track position (giving a timing of about one minute). Observing the anti-static precautions as before, remove the i.c.s and de-solder the sensor wires from the p.c.b.

MAIN CASING

Prepare the main-unit case by marking the mounting holes and drilling them through. Drill holes also for the sounder, the key-operated switch and for the sensor lead which will pass through. Drill holes (if necessary) to enable the presets to be adjusted from the outside using a thin screwdriver or trimming tool. Pass the sensor lead through its hole and apply a clamp or cable tie as in the sensor. Check that it is secure.

Solder the wires back on to the p.c.b. pads and, observing the anti-static precautions, insert the i.c.s into their sockets again. Mount the p.c.b. using plastic spacers on the bolt shanks. Attach the sounder noting that the hole must not be obstructed in any way to allow as much as possible of the sound to emerge. However, for testing, it would be wise to tape over the hole temporarily to reduce the sound output because it will be very loud.

Again refer to Fig.4. Connect the sounder wires to the screw terminal block observing the polarity. Attach the battery pack by means of a small bracket or another method of your choice. Make final tests and adjust VR2 to the required time period.

Attach self-adhesive plastic feet to the base to prevent scratching the work surface. Experiment to find the best position for the sensor attaching it temporarily using Blu-Tack. Note, however, that if it is placed too close to the main unit or mounted on the same surface, the sound from the audible warning device reaching it may be sufficient to keep the alarm triggered. This will be evident if the circuit fails to time-out.

When satisfied, glue the sensor unit in position. Obviously, if the sensor is subjected to a very violent shock, such as with shattering glass, it could be damaged, but this seems a small price to pay for security.

If using the Vibralarm as part of an intruder deterrent system, ensure that its sensitivity is suitably adjusted to prevent accidental triggering by, for example, the window cleaner, or thunder! ☐

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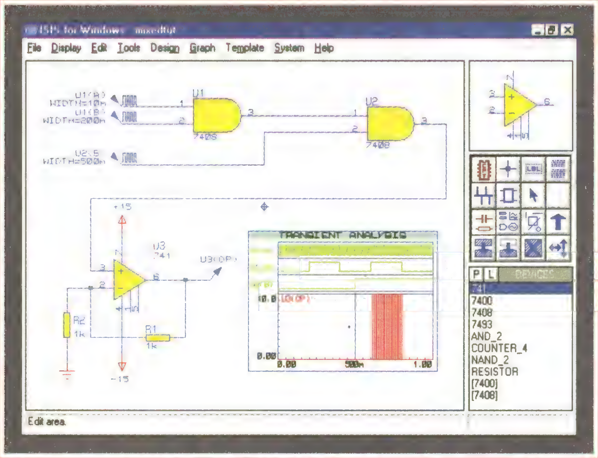

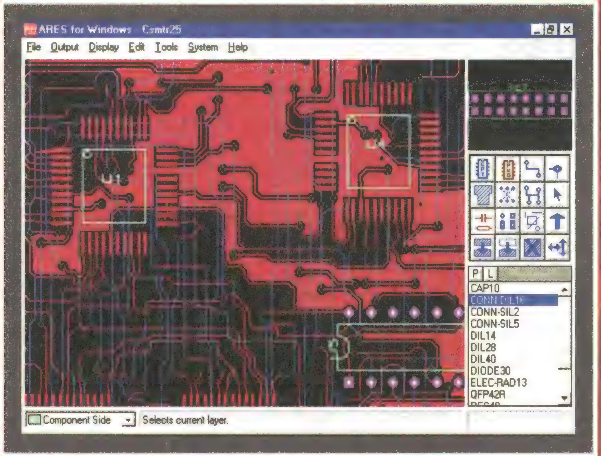

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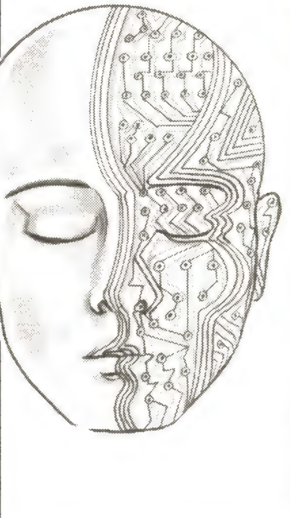

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One-Volt L.E.D. – A Bright Light

ILLUMINATING an l.e.d. from a very low supply voltage is difficult as most devices have a forward drop of at least 1·8V. This excludes their use in products operating from a single 1·2V or 1·5V battery. However, by applying techniques used in d.c.-to-d.c. converters, a very compact, economical and efficient solution can be produced. The circuit diagrams shown in Fig.1a to Fig.1c will brightly illuminate an l.e.d. from a supply as low as 750mV and as high as 1·5V, i.e., most single cell batteries available including nearly dead ones.

In the Micro-torch circuit Fig.1a, transistor TR1, transformer T1 and resistor R1 form a current-controlled switching oscillator. Each time TR1 turns off, the collapsing magnetic field in T1 generates a 30V (off-load) positive pulse at TR1's collector (c). This, in series with the supply, is fed directly to the l.e.d.

Switching occurs at a very high frequency and with a low duty cycle which results in an average l.e.d. current of about 18mA, sufficient to illuminate most l.e.d.s. Current, and therefore brilliance, can be increased by reducing the value of resistor R1 and vice versa. A value of 2 kilohms produces 30mA which is more than enough even for hyper-bright devices.

Conversion efficiency depends on transistor TR1. Although any transistor can be used, high performance devices with very low $V_{CE(SAT)}$ yield the best results; for the ZTX450, efficiency is 73 per cent. A ZTX650 increases it to 79 per cent whilst a BC550 reduces efficiency to 57 per cent. Even at this value it still out-performs conventional circuits using higher voltage supplies where efficiency rarely exceeds 50 per cent.

A micro-toroid centre tapped transformer, T1, is constructed using an anti-parasitic bead 6mm by 4mm in diameter with a 2mm hole. Fold 90cm of 38s.w.g. enamelled copper wire in half, press the crease tightly together and then thread the folded wire repeatedly through the bead hole until 20 turns are wound. Trim protruding wires to 25mm.

The bead now contains two sets of 20 turns with two starts at one extremity and two ends at the other. Join an appropriate start and end together to form the tap (CT). If the circuit fails to oscillate, check the tap is correctly formed; otherwise, it's most likely a shorted turn.

The simplest application, Fig.1a is a Micro-torch, power-on indicator or simple infrared transmitter. Indicators for use with other circuits are shown in Fig.1b and Fig.1c, the latter consuming no power when off. Diode D2 in Fig.1c raises the forward drop as some l.e.d.s leak when operated with a fresh alkaline battery; it is also necessary with infrared devices that have a forward drop of less than 1·5V.

When used with other circuits, decoupling with capacitor C1 in close proximity to the oscillator is recommended. Also keep lead lengths short, especially to the transformer, as the circuit operates at a high frequency; fortunately using a micro-toroid transformer significantly reduces radiation.

Z. Kaparnik,
Swindon, Wilts.

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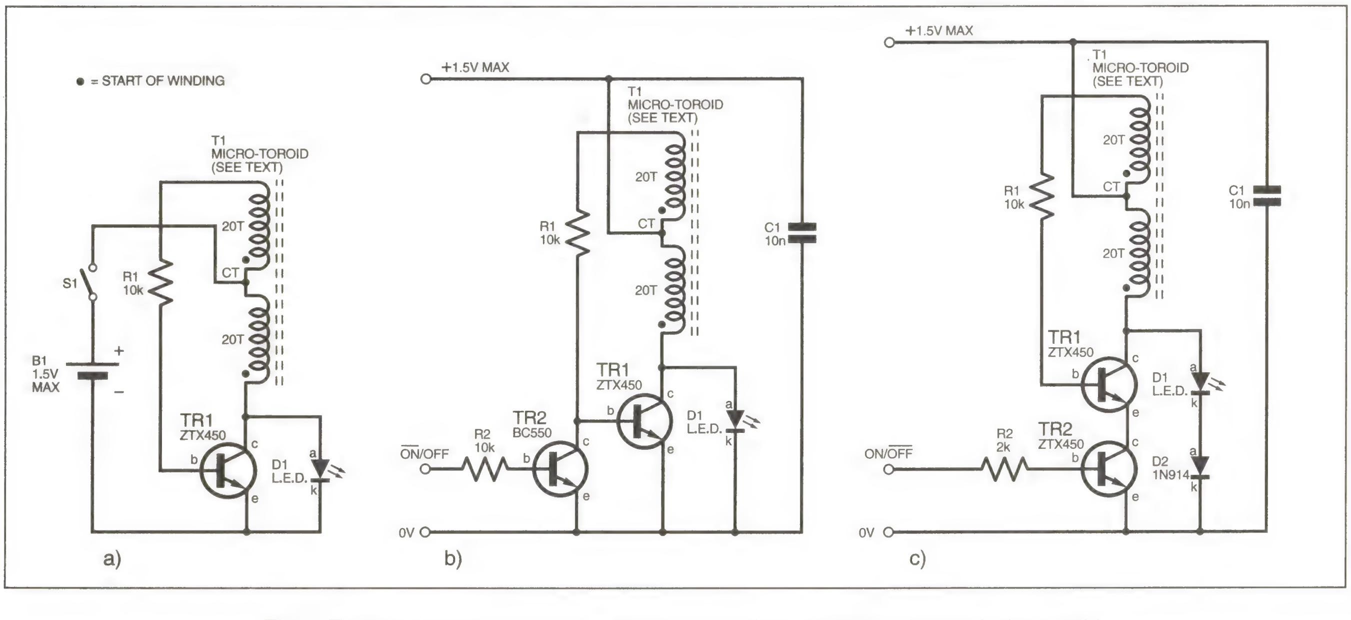

Fig.1. Three drive circuits for operating l.e.d.s from supply voltages below 1·5V.

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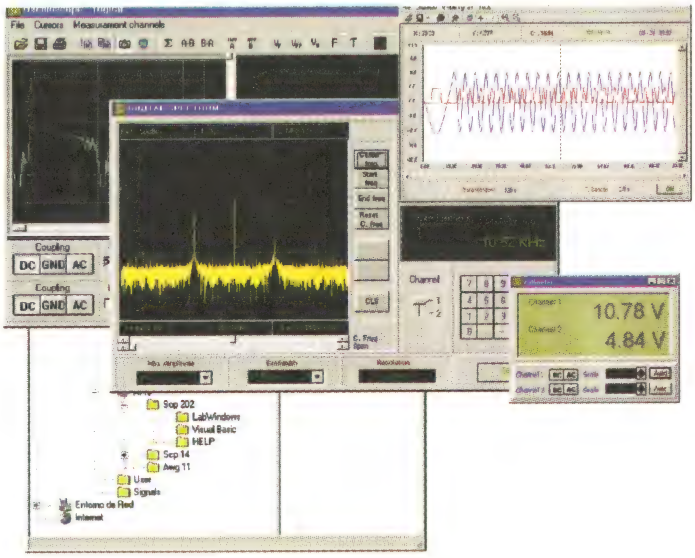

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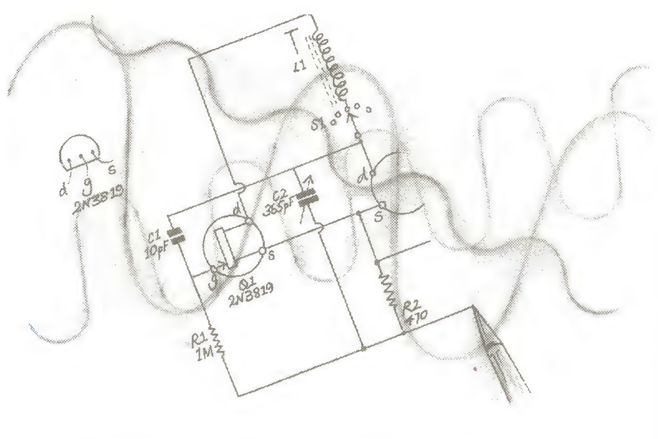


RAYMOND HAIGH

Most text books deal with oscillators in a theoretical way. This series, prepared with the electronics enthusiast and experimenter very much in mind, is intensely practical. Tried and tested circuits are fleshed out with component values, and their vices and virtues are exposed.

PART FIVE – CRYSTAL AND CRYSTAL CONTROLLED OSCILLATORS

PREVIOUS articles have described oscillators which rely upon tuned circuits formed by inductors and capacitors (*L*/*C*) to determine the operating frequency. Oscillators of this kind can be tuned over a wide frequency range and, with appropriate circuitry, deliver a sinusoidal waveform of good purity. Their only drawback is frequency drift, which becomes an increasing problem above 5MHz or so.

This month crystal and crystal controlled oscillators (XOs), which display a very high degree of frequency stability will be considered. Although some circuits permit the operating frequency to be "pulled" over a very narrow bandwidth (VXOs – variable crystal oscillators), crystal oscillators cannot be tuned as broadly as *L*/*C* oscillators: they are essentially spot-frequency signal generators.

BRIEF HISTORY

Many types of crystal, but particularly Rochelle salt and quartz, develop an electrical charge across opposite faces when they are distorted by mechanical stress. Changing the stress from pressure to tension reverses the polarity of the charge.

The phenomenon was called *piezoelectricity* (electricity through pressure) by Jacques and Pierre Curie who discovered it in 1880. A year later they demonstrated the converse: that stress could be set up in certain crystals by applying an electrical potential.

The effect remained a scientific curiosity until the First World War when a French scientist, Langevin, used it to detect acoustic waves produced by submarines. Spurred on by the developing radio industry, research was also taking place into the use of crystals for frequency control. In 1921, Professor W. G. Cady of the American Wesleyan University applied two pairs of terminals to a quartz crystal, connected it in the feedback path of a three valve amplifier, and discovered its remarkable frequency stabilising action.

He demonstrated his circuits to Professor G. W. Pierce of Harvard University in January 1923. Within a few months Pierce had developed an improved version, simplified by the use of a two terminal crystal, and his oscillator is still widely used today.

FREQUENCY RANGE

Crystal units can be produced to resonate at fundamental frequencies from 1kHz to above 100MHz, but range extremes are expensive and not readily available. Most retailers usually stock fundamental mode crystals with frequencies from 1MHz to 20MHz, and some carry a range extending from 32kHz to 30MHz.

Frequencies in excess of 20MHz are often generated by a crystal designed to resonate at an overtone frequency, usually the third or fifth harmonic of its fundamental: e.g., a crystal for 27MHz would have a fundamental of 9MHz. (Accuracy, particularly at frequencies in excess of 30MHz or so, is easier and cheaper to achieve in this way).

FREQUENCY OF OSCILLATION

Appropriate circuitry must be used or the frequency of an oscillator may differ slightly from that stamped by the manufacturer on the crystal case. It will, however, always be quite close, and where stability rather than absolute precision is the overriding consideration, this aspect of the technology can be ignored.

Departures from the quoted frequency of the crystal are caused by two factors. First, a crystal unit has two natural resonances. Second, its frequency can be shifted, or "pulled", by external reactances (inductance, *L*, or capacitance, *C*).

The lower of the two natural resonances occurs when the crystal is operating as a *series* tuned circuit. Its impedance is then at its lowest. The higher resonant frequency, also called the anti-resonance, is caused by the tuning effect of the "capacitor" formed by the crystal's electrodes, plus any stray circuit capacitance. Together with the inductive reactance of the crystal, this forms a *parallel* tuned circuit with a very high impedance.

The spacing between these two resonances, sometimes called the crystal bandwidth, being dependant upon electrode and stray capacitances, is subject to variation. Usually, however, it is between 0·05 per cent and 0·1 per cent of the stated frequency.

LOADING UP

Most crystals are intended for operation in the parallel mode, and the manufacturers quote a loading capacitor value (usually 30pF) which must be connected to ensure oscillation at the stated frequency. In practice, this loading capacitor, or part of it, often comprises a trimmer capacitor which can be adjusted to compensate for stray circuit capacitance and set the frequency of oscillation very precisely. Crystals cut to give the specified frequency when connected in the series mode, i.e., used as series tuned circuits, do not require a loading capacitor.

It should be noted that the mode of operation is determined by the external circuitry. Any crystal unit will oscillate at its resonant and at its slightly higher anti-resonant frequency.

CRYSTAL MANUFACTURE

Quartz is a crystalline form of silicon dioxide (SiO_2). When the technology was in its infancy, resonators were cut from naturally occurring crystals, but the use of synthetic quartz is now almost universal.

Unique characteristics, coupled with low manufacturing costs, have brought about the widespread use of quartz crystals in clocks, watches, computers, navigation systems, and every item of equipment where a precise, drift-free, spot-frequency generator is required.

Demand for crystal units is so great that the world-wide manufacture of synthetic quartz now exceeds 2000 tons per year.

We come now to the second factor influencing the frequency of oscillation: external reactances. Capacitance placed in series with the crystal will raise its frequency of oscillation; capacitance wired in parallel will lower it. Series resonant crystals (where there is no external parallel capacitor) can have their frequency lowered by means of a series connected inductor.

PULLING POWER

Just as external reactances can be connected to set the crystal to its correct operating frequency, they can also be used to "pull" it over a narrow band of frequencies. An oscillator configured in this way is known as a variable crystal oscillator (VXO).

How much the crystal can be "pulled" is determined by its mechanical springiness. Although crystals can be manufactured with a high degree of "springiness", it should be noted that the amount of pulling is, at best, limited to a very small percentage (around 0·15) of the crystal's resonant frequency, and this percentage tends to reduce as the operating frequency decreases.

Units designed to resonate at an overtone resist "pulling" at the overtone frequency because stiffness increases rapidly with overtone number. They are, however, often particularly responsive at their fundamental frequency.

FREQUENCY DRIFT

Simple oscillators in which resistors and capacitors (*R/C*) are used as the frequency determining components can achieve a frequency stability of around one part per thousand. When tuned circuits comprising inductors and capacitors (*L/C*) fix the frequency, stability is usually of the order of one part per ten thousand.

QUARTZ CRYSTAL UNITS

Mechanical stresses are induced in a slice of quartz when a voltage is applied across its opposite faces. An alternating voltage of the correct frequency will make it vibrate or resonate in the same way that a violin string resonates. Resonant frequency is determined by the mass of the crystal and its connecting electrodes. Fundamental resonances can range from 1kHz to more than 250MHz, although 100kHz to 30MHz is common.

In use, the crystal simulates an *L/C* tuned circuit with a *Q* factor which can, theoretically, exceed a million. (The very best inductor-capacitor combinations seldom achieve *Q* factors in excess of 300).

A near zero coefficient over a fairly wide temperature range can be obtained by cutting the slice from the bulk crystal at a particular angle. This feature, together with the remarkable *Q* factor, enables crystal units to impart a high degree of frequency stability to oscillatory circuits.

Basic crystal controlled oscillators can have a stability better than five parts per million, even when no special precautions are taken to minimise drift. When temperature control measures are incorporated, a stability of one part per million is achievable, and, if special care is taken, this can be further improved by a factor of ten.

Clearly, therefore, when a spot frequency has to be generated, and when freedom from drift is of paramount importance, there is no practical substitute for a quartz crystal oscillator. Crystal oscillators must, however, be buffered, and regard must be had to all of the other drift reducing measures outlined in Part Two, if the highest levels of stability are to be achieved.

PIERCE OSCILLATOR

One of the earliest crystal oscillators, still widely used, is the Pierce oscillator. In an updated version, the crystal is connected between collector and base of a transistor or drain and gate of a f.e.t. (field effect transistor).

A bipolar transistor version of Pierce's early valve circuit is given in Fig.1, where a quartz crystal, X1, is connected between the collector (c) and base (b) of TR1. The transistor is biased by resistor R1, and the output is developed across the r.f. choke L1.

The crystal is operated in the parallel mode and its loading capacitor is formed by C1 and trimmer capacitor VC1, which are effectively connected in series across it. The frequency of oscillation can be adjusted, within narrow limits, by VC1, which is usually a miniature film-dielectric trimmer. (An air-spaced component should be used if maximum freedom from drift is required).

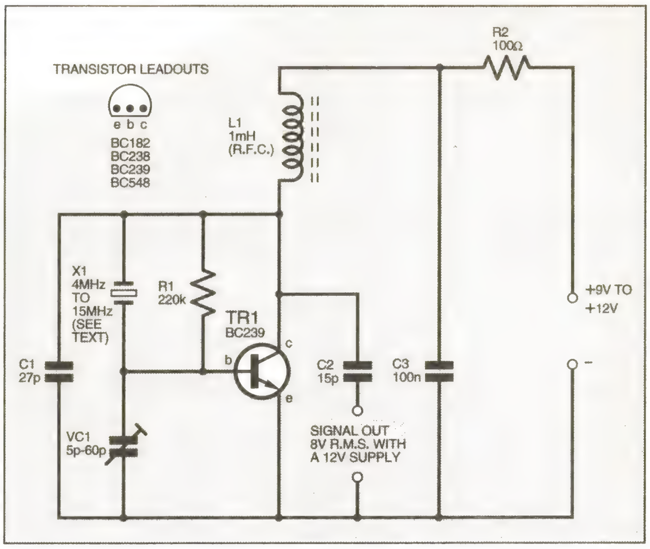


Fig.1. An updated bipolar transistor version of Pierce's valve-based crystal oscillator

The values of C1 and VC1 should prove suitable between 4MHz and 15MHz, but they may need increasing for lower and reducing for higher frequencies. With this version, oscillation is usually at its most vigorous when the capacitance provided by VC1 is approximately twice that of C1.

Some low frequency (1MHz and below) crystals can be "sluggish" and if difficulty is encountered, a 4·7mH choke as a collector load should make the circuit oscillate.

Output is taken from the collector via d.c. blocking capacitor C2. The value of this component should be kept as low as possible consistent with sufficient signal being delivered to the accepting circuit. The oscillator is decoupled from the power supply by means of resistor R2 and capacitor C3.

F.E.T. Version

A Pierce oscillator maintained by a f.e.t. is shown in Fig.2, and the circuit is very similar to the bipolar version. The gate (g) of TR1 is grounded via resistor R1 in order to ensure correct operation, and source (s) biasing is provided by resistor R2 with its bypass capacitor C2.

The source bias components must be provided when a J310 transistor is used, but they can be omitted with a 2N3819 and the source directly grounded. This modification will increase output to around 5V r.m.s.

It is customary with f.e.t. oscillators to connect a silicon signal diode (a 1N4148 with cathode grounded) between gate and the negative rail in order to limit oscillation amplitude and prevent forward conduction of the f.e.t.'s gate. With this circuit the measure can result in erratic and uncertain operation above 10MHz, and for this reason a diode has not been shown.

Amplitude limitation is, however, desirable in the interests of minimising drift and optimising waveform quality, and it is good practice to connect a diode whenever other aspects of performance are not compromised.

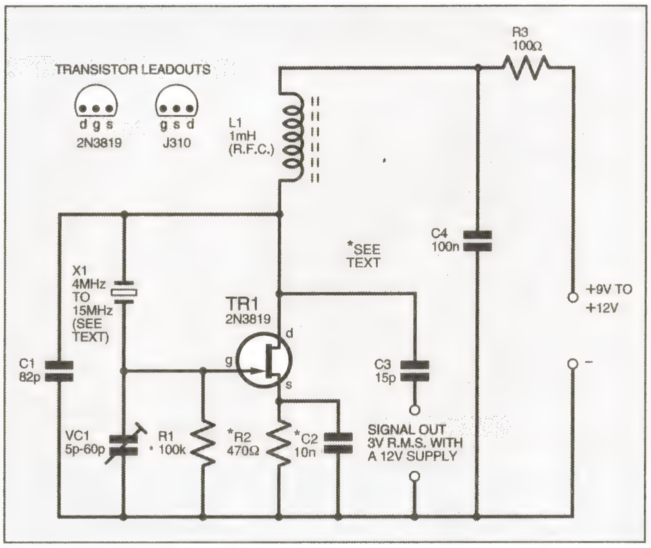


Fig.2. Field effect transistor (f.e.t.) version of the Pierce crystal oscillator.

Again, the values of C1 and VC1 should prove suitable between 4MHz and 15MHz, but they may need increasing at lower and reducing at higher frequencies. Oscillation is usually at its most vigorous with this circuit when C1 is approximately twice the value of VC1; i.e., the reverse of the situation with the bipolar circuit. It would seem that the capacitors and crystal are acting as an impedance-matching π tank circuit.

LOGIC OSCILLATOR

Logic gates can be used as the active devices in a Pierce oscillator, and circuits using one or two gates are common in digital systems. Stability is inferior to that afforded by well constructed crystal oscillators using discrete components, but it is still of a very high order.

A typical circuit is shown in Fig.3, where two of the four NOR gates in a 4001B i.c. are used. The maintaining device is formed by IC1a, and IC1b acts as a buffer stage, the two inputs of each gate being strapped together to produce a pair of inverting amplifiers.

Quartz crystal X1 is connected between the output (pin 3) and input (pins 1/2) of IC1a, and the operating conditions of the stage are stabilised by resistor R1. Again, VC1 together with C1 act as the loading capacitors, and the frequency of oscillation can be adjusted slightly by means of VC1.

The output from IC1b (pin 4) is in the form of a square wave with a peak-to-peak value almost equal to the supply voltage. A tolerable sinewave output can be taken, via a low value capacitor, from pin 1 and pin 2 of IC1a. Supply line decoupling capacitor C2 should be mounted close to pin 14 of the chip.

With CMOS (complimentary metal oxide semiconductor) devices, propagation delay (the time taken for the output to change in response to a change of state at the input) is particularly dependant upon supply voltage. The circuit will oscillate readily at 3MHz or 4MHz with a 5V supply, but 12V has to be applied to ensure reliable oscillation at 8MHz. The maximum "safe" voltage is 15V.

Some versions of the circuit include a 10 kilohm or 100 kilohm resistor in the feedback path (between the output of IC1a and the junction between X1 and C1). This resistor reduces the drive to the crystal and, together with C1, acts as a low-pass filter, inhibiting oscillation at other than the fundamental crystal frequency.

Reducing feedback levels is always desirable in order to minimise drift, but the circuit will be less ready to oscillate at its upper frequency limit, or with "sluggish" crystals. Moreover, no problems with spurious frequencies were encountered with the circuit as shown in Fig.3.

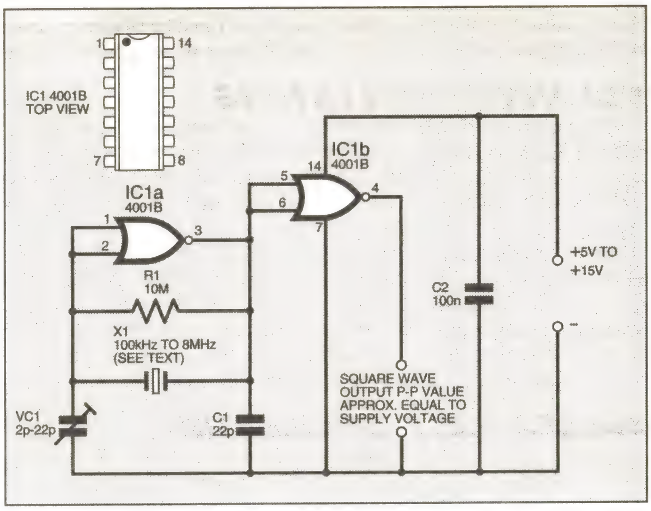


Fig.3. Circuit for a CMOS logic gate version of the Pierce crystal oscillator.

CLAPP OSCILLATOR
– Bipolar Transistor Version

A bipolar transistor Clapp crystal oscillator is shown in Fig.4. Transistor TR1 is biased by resistors R1 and R2, and feedback, developed across emitter resistor R4, is applied to the capacitive tapping formed by C1 and C2. These components swamp the voltage and temperature variable internal capacitances of TR1, and in this way the feedback circuitry helps to combat drift.

The output signal is often taken from the emitter terminal of TR1, but, in this version of the circuit, the output is developed across the collector load resistor R3, thereby affording a small measure of isolation from the frequency determining components. Notwithstanding this, the d.c. blocking capacitor C3 should be as small as possible consistent with the delivery of sufficient signal voltage. Collector load resistor R3 must not have a greater value than emitter resistor R4 or oscillation will be inhibited. The circuit is decoupled from the power supply by capacitor C4 and resistor R5.

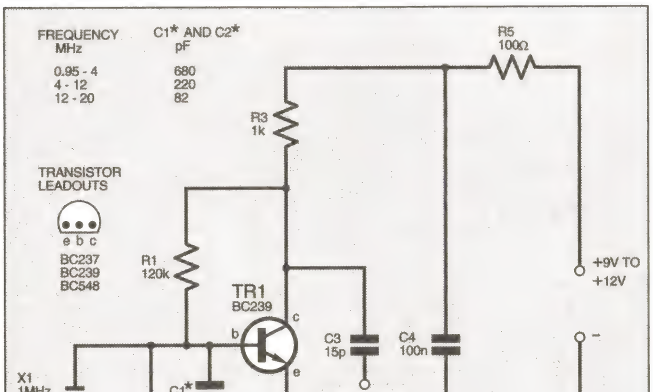


Fig.4. Circuit for a bipolar transistor version of the Clapp crystal oscillator.

Trimming capacitor VC1 is connected in series with the crystal X1, thereby forming the Clapp variant of the Colpitts circuit. It enables the frequency to be adjusted over the usual narrow limits. If the greatest possible freedom from drift is required, the bulk of this series capacitance should be made up of fixed components selected by trial and error to produce an optimum combination of temperature coefficients.

Feedback capacitors C1 and C2 are not excessively critical and the quoted values should ensure reliable oscillation. Making capacitor C2 larger than C1 will reduce feedback, minimise drift, and may improve output waveform. Again, the trial and error selection of capacitors with the most favourable temperature coefficients will help to ensure a high degree of stability.

– F.E.T. Version

A field effect transistor version of the circuit is given in Fig.5. These devices are less active than their bipolar counterparts, and an r.f. choke has to be used as a source load in order to ensure sufficient feedback. Signal output is taken from the source (s) via d.c. blocking capacitor C3.

Feedback capacitors C1 and C2 have a lower value with this circuit, but the comments made earlier regarding selection apply equally here. If a J310 f.e.t. is substituted for the 2N3819, a 470

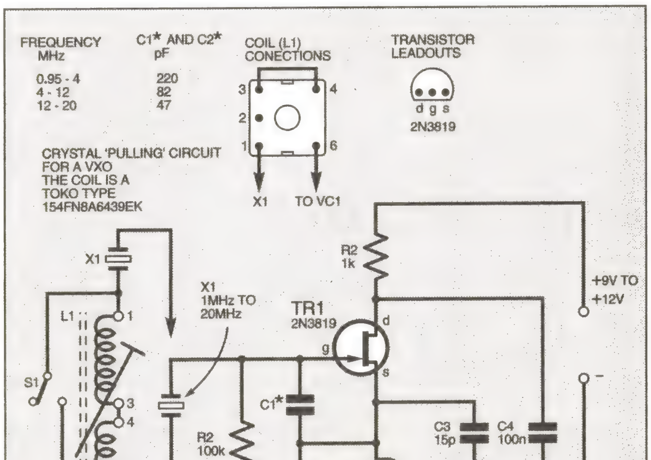


Fig.5. Field effect transistor version of Clapp crystal oscillator.

ohm resistor, bypassed by a 10nF capacitor, must be placed in series with the "grounded" end of the r.f. choke to ensure correct biasing.

COLPITTS OSCILLATORS

By omitting series trimmer VC1 in the circuits shown in Fig.4 and Fig.5, and connecting the crystal directly between base or gate and ground (0V), a Colpitts oscillator is formed. Frequency adjustment can then be provided by including a small trimmer capacitor as part of C1 or C2.

With so much capacitance in parallel with the crystal, it is likely that adjustment of the trimmer will fail to lift the frequency of oscillation up to the figure quoted by the manufacturer. If precise operating frequency is important, the values of capacitors C1 and C2 should, therefore, be reduced, consistent with reliable oscillation. (The series connected capacitor, VC1, in the Clapp circuit avoids this problem).

MILLER F.E.T. OSCILLATOR

A f.e.t. version of Miller's early valve oscillator is shown in Fig.6. Miller's circuit has much in common with Armstrong's tuned grid/tuned anode arrangement, but here a quartz crystal replaces the *L/C* tuning connected between grid (now gate) and negative rail or ground.

The *L/C* circuit, which acts as TR1 drain (d) load, is tuned to the crystal frequency (or a harmonic) and a high level, high impedance output can be taken from the drain. A coupling winding on the coil can be used to provide a low impedance output, and the connections for inductors in the Toko range are also shown.

The frequency coverage afforded by Toko and hand-wound coils has been tabulated in earlier articles. Below 2MHz, this oscillator starts more readily if there is a relatively high ratio of capacitance to inductance in the tuned circuit (approximately 500pF and 50mH at 1MHz).

Limiting diode D1 and the source (s) bias components, R2 and C2, improve the operation of this circuit, and the output waveform is of good quality.

CRYSTAL CONTROLLED

In the circuits considered so far, the crystal unit has replaced an *L/C* tuned circuit and oscillation would not occur without it. These circuits should, therefore, be regarded as crystal oscillators.

A crystal unit can be inserted in the feedback path of an *L/C* oscillator so that sufficient feedback can only occur at the crystal's resonant frequency. Circuits of this kind are known as crystal *controlled* oscillators.

A crystal controlled f.e.t. version of Armstrong's tuned anode oscillator (now tuned drain) is given in Fig.7. Drain tuning is accomplished by coil L1 and capacitor C1, and coil L2 is a coupling winding supplying feedback to the gate.

Crystal X1, placed in series with L2, offers very little opposition to the feedback at its series resonant frequency, and a very high reactance at all other frequencies. In this way, the crystal controls the oscillator. The tuned circuit formed by L1 and C1 must, of course, resonate at the crystal frequency or a harmonic.

Signal output is taken from the drain and the impedance at this point is very high. Unless the accepting circuit has a matching high impedance, the signal voltage delivered to it will be much less than the stated 4V r.m.s.

Connection details for Toko coils are also given in Fig.7. The circuit will oscillate even when the feedback winding is wrongly connected (it then functions as a tuned-drain-tuned-gate oscillator). Oscillation is weaker, however, and harmonics of the fundamental crystal frequency will only be generated when the feedback winding L2 is connected as shown.

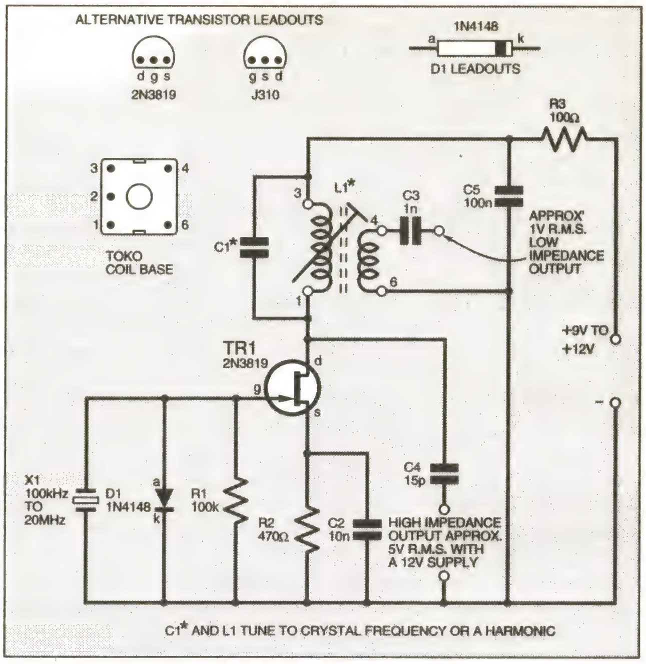
BUTLER OSCILLATOR

A crystal controlled Butler oscillator is shown in Fig.8. Butler's circuit was described in its *L/C* form in Part Three, and it will be recalled that it ingeniously matches the impedances of two source coupled f.e.t.s and the tuned circuit formed by coil L1 and capacitor C1.

In this version, crystal X1 is placed in the feedback path between the drain (d) of TR1 and the gate (g) of TR2, where it inhibits feedback at all but its series resonant frequency.

A more conventional arrangement is to use separate 1 kilohm source resistors and to couple the sources via the controlling crystal. A feedback capacitor of between 10pF and 100pF, depending on frequency, then links the drain of TR1 to the gate of TR2.

Sluggish low frequency crystals may, however, be unable to initiate oscillation when connected in the low impedance path between the sources. Success is, therefore, more certain with the arrangement shown in Fig.8.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1N4148
a
k
D1 LEADOUTS
TOKO COIL BASE
3
4
2
1
6
R3 100Ω
L1*
C3 1n
C5 100n
APPROX' 1V R.M.S. LOW IMPEDANCE OUTPUT
C1*
TR1 2N3819
d
g
s
+9V TO +12V
-
X1 100kHz TO 20MHz
D1 1N4148
R1 100k
R2 470Ω
C2 10n
C4 15p
HIGH IMPEDANCE OUTPUT APPROX. 5V R.M.S. WITH A 12V SUPPLY
C1* AND L1 TUNE TO CRYSTAL FREQUENCY OR A HARMONIC

Fig.6. Circuit for a field effect transistor version of the Miller crystal oscillator.

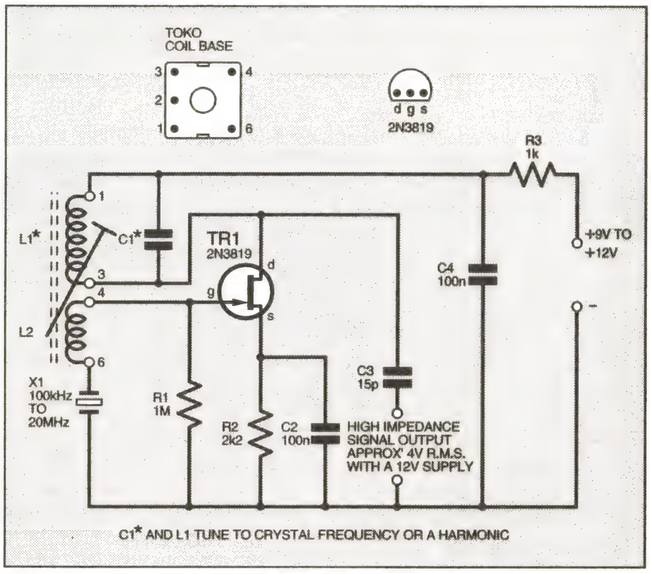

Fig.7. Crystal controlled version of Armstrong's tuned anode (now drain) oscillator.

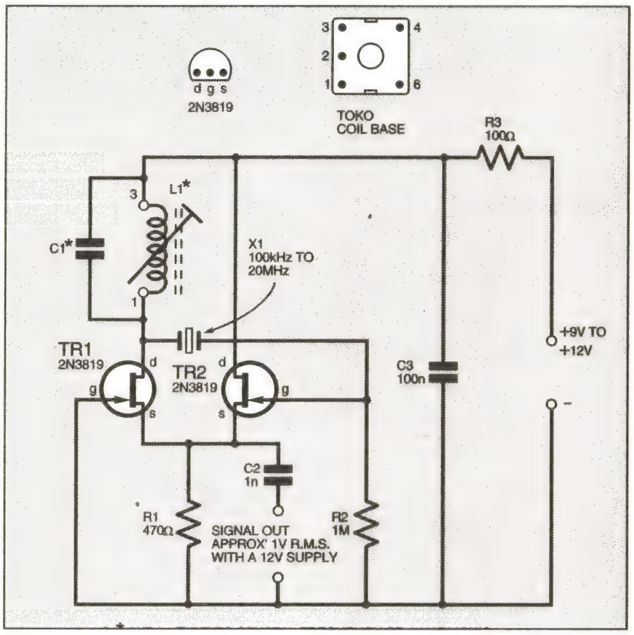

Fig.8. Crystal controlled Butler oscillator.

RESONANT FREQUENCIES

Quartz crystal units resonate at two, closely spaced frequencies. The lower frequency is produced when the unit is operated in the series mode, simulating a series tuned circuit. In this mode, the impedance presented by the crystal at resonance is low.

The capacitor formed by the connecting electrodes deposited on opposite faces of the crystal slice tunes it to a slightly higher frequency. This is known as the parallel or anti-resonant frequency. In this mode the crystal simulates a parallel tuned circuit and its impedance is very high.

Most crystals are manufactured for use in the parallel mode with a small external loading capacitor which sets the resonant frequency to the stated value. Series mode crystals do not require a loading capacitor.

All crystals will resonate in both modes, and the frequency can be slightly low or high if the wrong type of crystal is used.

Again, the tuned circuit formed by L1 and C1 must resonate at the crystal frequency or a desired harmonic. Signal output is at a low impedance and isolated, to some extent, from the frequency determining components. When the crystal couples the sources, a high impedance output is usually taken from the drain of TR1.

The crystals in the circuits shown in Fig.7 and Fig.8 are operating in their series mode and, in theory, series mode devices should be used or the frequency of oscillation will be slightly lower than the figure stated by the manufacturer. In practice, the frequency can usually be set to the stated value by adjusting the core of L1, even when parallel mode crystals control the circuit. This is not the case when the crystal couples the sources in the Butler circuit, and a series mode unit *must* be used with this arrangement.

VARIABLE FREQUENCY

When external reactances are used to "pull" a crystal across a band of frequencies, the circuit is known as a *variable* crystal oscillator, or VXO. Stability deteriorates as frequency shift increases, and oscillation may cease, or the crystal lose control, if the process is carried too far.

A typical "pulling" circuit is included in Fig.5, where inductor L1 and variable capacitor VC1 are placed in series with the crystal X1. A VXO can also be formed by connecting these components in series with the crystal in Pierce's circuit, given in Fig.3. However, this arrangement does not permit the grounding of VC1's moving vanes, and the modification is best made to the Clapp crystal oscillator.

Inductors of between 5μH and 20μH are usual in these circuits: increasing the value above 20μH in an attempt to pull the frequency lower may inhibit oscillation. The specified coil, with its windings connected in series, can be set between approximately 6μH and 12μH by adjusting its cup core.

When the widest possible "pulling" range is required, provision must be made for shorting out this inductor. Shorting switch S1 should be operated by a miniature signal-switching relay located very close to the coil.

When this arrangement is adopted, a 14MHz crystal can be shifted around 0·15 per cent (i.e. 20kHz). The percentage increases with rising crystal frequency. Stray circuit capacitances must, however, be kept to an absolute minimum or the frequency coverage will be seriously curtailed.

HARMONICS

Although advances in manufacturing techniques have made it possible to produce crystals which will oscillate, in fundamental mode, well in excess of 100MHz, it is still commonplace to use a harmonic of a lower frequency crystal when a signal above 20MHz or 30MHz is required.

With harmonic oscillators, frequency multiplication takes place within the maintaining amplifier and is controlled by an *L/C* tuned circuit in the output stage. Almost any oscillator where the output is developed across a tuned circuit (see Figs. 6, 7 and 8) can be adjusted to deliver at least a close harmonic.

A circuit which will operate at higher crystal harmonics is given in Fig.9, where transistor TR1 is configured as a Colpitts oscillator and its base bias is fixed by resistor R1 and preset VR1. Preset VR1 enables the bias to be optimised for different transistor types when operation becomes more critical above 50MHz or so. A transistor with an f_T at least three times higher than the required harmonic is necessary for the reliable operation of the circuit.

Feedback is developed across r.f. choke L2 and applied to TR1 base via the capacitance tapping formed by capacitor C1 and trimmer capacitor VC1. The feedback capacitors C1 and VC1 also act as the loading for the crystal X1, and the inclusion of trimmer VC1 permits the fundamental to be set to the correct frequency. Emitter bias is provided by resistor R2, which is bypassed by capacitor C3.

A high impedance output is developed across the collector load formed by tuned circuit L1/C2. This tuned circuit must, of course, be adjusted to resonate at the desired harmonic of the crystal frequency. An alternative low impedance output could be provided by using a coupling winding on the coil, as shown in Fig.6.

As the output frequency increases above, say, 50MHz, capacitor C1 can be reduced or even omitted (the internal base/emitter capacitance of TR1 can be sufficient to maintain oscillation). Substituting an r.f. choke of lower inductance may also be of benefit. Whatever the frequency, optimum performance is usually realised when VC1 has an in-circuit value of around twice that of C1.

OVERTONES

Overtone oscillators use specially cut crystals which resonate at an odd harmonic, usually the third or fifth, of their fundamental. Whilst crystals of this kind can be made to oscillate at their fundamental frequency, they are designed to resonate, or vibrate, at a stated overtone.

This represents the crucial difference between overtone and harmonic oscillators. In an overtone oscillator, the crystal itself is vibrating at the higher frequency: in a harmonic oscillator, the crystal vibrates at its fundamental frequency and multiplication takes place within the transistor.

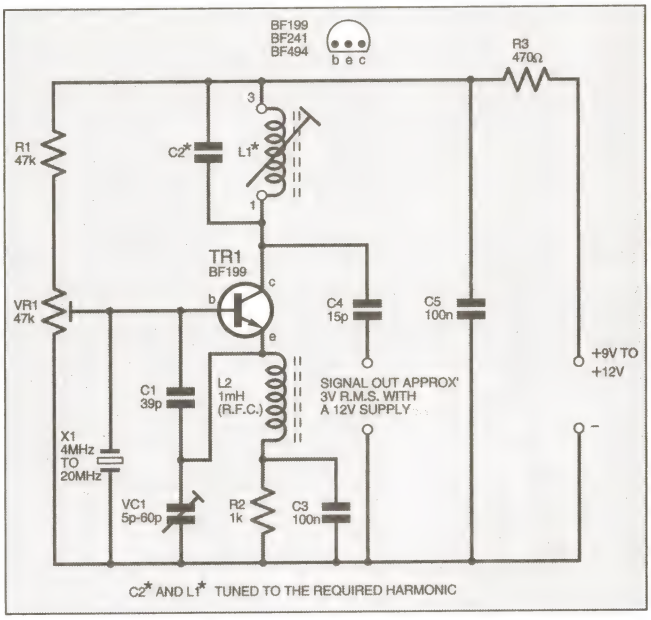

Fig.9. Circuit diagram for a harmonic and overtone crystal oscillator.

Sometimes measures are taken to suppress any tendency of an overtone circuit to oscillate at the crystal fundamental. Arranging for the feedback to reduce at the lower frequency is a common method.

In Fig.9, feedback is developed across r.f. choke L2. If this component is replaced by an inductor of much lower value, feedback will be insufficient to maintain oscillation at a fundamental of, say, 9MHz, but will be capable of doing so at the third overtone of 27MHz.

Inductors from the Toko S18 range are ideal for this purpose, and a 5·5 turn ferrite slug tuned coil (nominal value 0·23μH) should prove suitable for crystals with fundamentals in the 6MHz to 12MHz range. Temporarily substituting a tuned circuit which resonates at the fundamental for L1 and C2, will enable activity in this mode to be checked.

If the oscillator is producing an output at the crystal's fundamental, withdraw the core of the S18 coil until it stops. The relative values of capacitors C1 and VC1, and the gain and f_T of TR1, also influence the feedback level, and some experimentation may be necessary to eliminate unwanted oscillations. The circuit is, however, quite easy to set up.

DIVIDING DOWN

Crystals cut to resonate below 1MHz become more expensive and less readily available as the frequency is lowered. If a square wave output can be tolerated, bistable flip-flop (divide by two) and decimal counter (divide by ten) i.c.s can be used to produce submultiples of a higher frequency.

There is some additional complication, but the CMOS i.c.s are inexpensive and require no external components other than a supply decoupling capacitor.

If a sinewave output of good quality is the priority, an *L/C* oscillator will usually be more than sufficiently drift free at frequencies below 100kHz, especially if the precautions detailed in Part Two are observed.

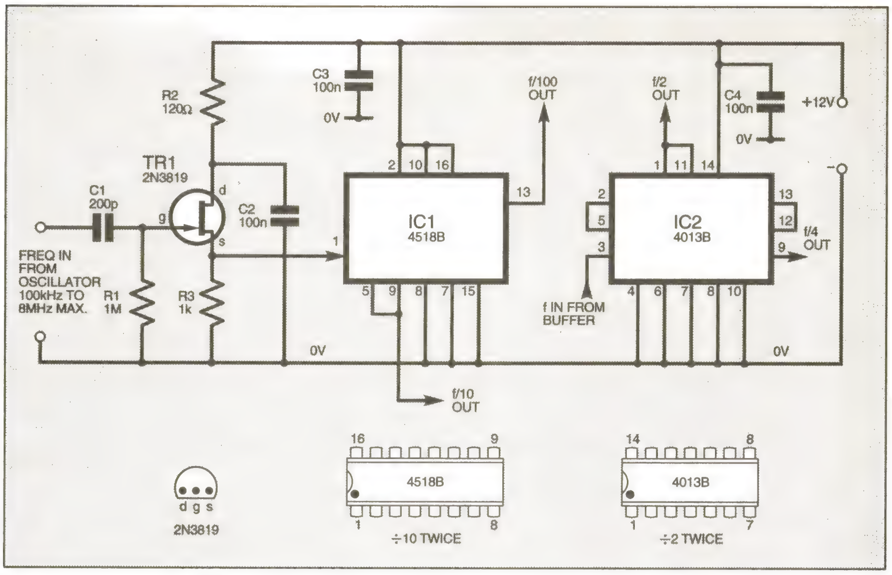

Fig.10. Circuit diagram for dividing the frequency down using a CMOS dual decimal counter i.c. plus a dual bistable flip-flop i.c.

DIVIDING DOWN

Crystals which resonate below 1MHz tend to be more expensive and less easy to obtain. If a square wave output can be tolerated, highly stable low frequency signals can be obtained, at lower cost, by using integrated circuits (i.c.s) to divide down the output from a higher frequency crystal.

A divider circuit using a dual decimal counter, IC1, that can be used to divide a frequency by 10 or 100, is shown in Fig.10. By this means, a 2MHz crystal would provide outputs at 200kHz and 20kHz. Alternatively, IC2, a dual bistable flip-flop, will divide by 2 or 4, and the two devices can be connected in tandem to produce various submultiples of the input frequency.

A source follower buffer stage, TR1, is necessary to ensure reliable operation of the i.c.s. Direct connections must be made between the buffer and the i.c.s and between any i.c.s in a dividing chain: a d.c. blocking capacitor is not required. The f.e.t. buffer stage is not needed when the dividers are used with the CMOS logic gate oscillator shown in Fig.3.

Output is a near perfect square wave with a peak-to-peak value almost equal to the supply voltage. The maximum input frequency for the i.c.s is around 8MHz when the supply voltage is 12V or 15V.

Next month: Oscillators which use *R/C* (resistor and capacitor) networks to fix the operating frequency will be considered.

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Starter Project

ACOUSTIC PROBE

ROBERT PENFOLD

An audio "telescope" or stethoscope to investigate distant or low level sound.

THIS project could be regarded as the audio equivalent of a telescope. Its basic function is to pick up sounds via a microphone, greatly amplify the resultant signal, and then feed it to a pair of headphones. This gives users a sort of "larger than life" version of what they would normally hear, permitting them to detect sounds that would otherwise be inaudible. A sort of hearing aid for those who do not have a hearing defect.

Apart from making sounds louder, it is often possible to place the microphone very close to the sound source, or even actually touching it, so that otherwise inaudible sounds can be monitored. When used in this way the unit acts as a sort of electronic stethoscope, and the barely audible sound from a watch can be made to sound more like a shipyard in full production. It is even possible to place the microphone underwater, perhaps to monitor the wildlife in a pond, provided, of course, the microphone is given adequate waterproofing.

The unit is small and self-contained, although a separate microphone can be used if preferred. An electret type is used whether the microphone is built-in or external to the main unit. A low cost insert will suffice if an internal microphone is used, and should provide excellent audio quality.

The output signal is monitored using headphones or an earphone rather than a loudspeaker, because the latter gives problems with acoustic feedback. This feedback produces the whistling and howling sounds that dog so many PA systems. These are largely avoided using headphones, and are totally eliminated using an earphone.

CIRCUIT OPERATION

The full circuit diagram for the Acoustic Probe is shown in Fig.1. The input circuit may look a little unusual, but it has to be borne in mind that an electret microphone insert has an integral buffer amplifier. Furthermore, the load resistor for the j.f.e.t. (junction gate field effect transistor) used in the buffer amplifier is usually absent, and must be included in the main circuit. Resistor R1 and capacitor C2 provide a well decoupled supply to the microphone insert, and also drop the supply voltage to a more suitable level. R2 is the load resistor for the j.f.e.t. in the microphone insert (MIC1).

Resistors R1, R2, and capacitor C2 should be omitted if the unit is used with an external electret microphone having a built-in battery supply for the preamplifier. Apart from the fact they would be superfluous they could also prevent the microphone from working properly.

HIGH GAIN

It is essential for the circuit to have very high voltage gain due to the low output level from the microphone. When dealing with faint sounds the output voltage from the microphone is likely to be microvolts rather than millivolts.

A two-stage amplifier is therefore used, employing IC1 to provide the initial amplification. The input stage is a standard inverting mode type having its voltage gain set at 40dB (100 times) by negative feedback resistors R3 and R6.

Resistors R4 and R5 form a potential divider that supplies the usual mid-supply bias potential to the non-inverting input of IC1. Capacitor C5 couples the output of IC1 to a simple common emitter amplifier based on transistor TR1. This provides a similar level of voltage gain to the input stage, giving an overall voltage gain of about 80dB (10,000 times) or so.

Capacitor C6 couples the output signal to the earphone or headphones. Good results are obtained using either a crystal earphone or medium impedance headphones of the type sold as replacements for use with personal stereo units. The unit is unlikely to give worthwhile results with a low impedance earphone or any other type of headphones. The current consumption of the circuit is about eight milliamps.

VOLUME AND NOISE

The high gain of the unit produces a potential problem with excessive volume from sounds at medium to high levels, or if the microphone is accidentally knocked. There are two ways around this, which are limiting and an automatic gain control circuit. Limiting is the method used here, and it is the more simple of the two. It simply entails limiting the maximum drive level from the output stage so that excessive volume levels cannot be produced. This has the advantage of being instant in operation, and the unit will operate normally as soon as a high input level has dropped back within normal operating conditions.

The drawback of limiting is that quite severe distortion is produced on high level signals. This is not really a major drawback since the unit is only intended for investigating sounds at low levels. The limiting is provided by using a simple output stage

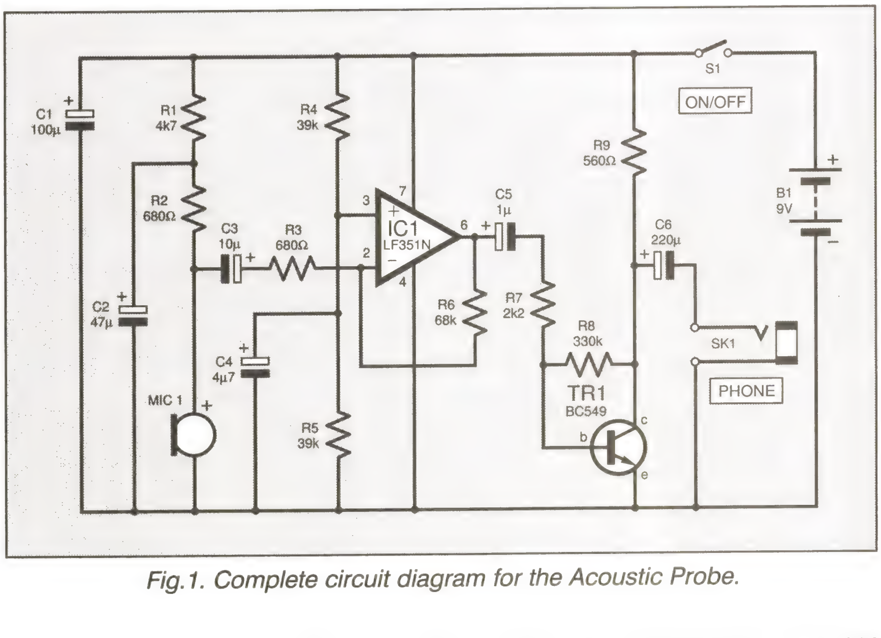


Fig.1. Complete circuit diagram for the Acoustic Probe.

that is unable to drive the earphone or headphones at very high volumes, and effectively has built-in limiting.

On the face of it, the higher the gain of the circuit the better it will perform. Unfortunately, it is not practical to use ultra-high gains in order to enable extremely quiet signals to be detected.

The lowest sound level that can be detected is mainly governed by the signal-to-noise ratio of the amplifier's input stage. Increasing the gain of the circuit simply results in proportionately more "hiss" type noise from the headphones, with low level signals being lost in this noise.

Regardless of the amount of gain used, signals below a certain level will be too far below the noise level to be detectable. The LF351N specified for IC1 is an inexpensive device that gives quite good noise performance. However, a high quality audio operational amplifier such as the NE5534AN will provide a significantly lower signal to noise ratio and extend the capabilities of the unit.

CONSTRUCTION

The circuit board is based on a piece of stripboard that has 30 holes, by 16 copper strips. Details of the component layout and wiring, together with the breaks in the copper strips are shown in Fig.2. The high gain of this circuit make it vulnerable to problems with instability due to stray feedback, so unless you know what you are doing it is best to copy the layout shown here rather than experimenting with your own design.

Construction of the board follows along the normal lines, and starts with a board being trimmed to size using a hacksaw. The rows of holes are very close together so cut along rows rather than trying to cut between them. There will inevitably be some rough edges and corners, but the board is easily filed to a neat finish.

Next drill the two 3·3mm diameter mounting holes and make the eight cuts in the copper strips. The cuts can be made using the special tool or a hand-held twist drill bit of about 5mm in diameter. Make sure that the copper strips are cut across their full width.

The stripboard is then ready for the components to be fitted. Start with the resistors and link wires. Only three links are required and they are quite short, so trimmings from the resistor leadouts should suffice for these. Then fit the capacitors, making sure that each one has the correct polarity.

Now fit transistor TR1 and an 8-pin d.i.l. holder for IC1. The LF351N used for IC1 is not a static-sensitive device, but it is still a good idea to mount it on the board via a holder.

Use single-sided solder pins at the points where the board will connect to MIC1, S1, SK1, and the battery; it is one millimetre diameter pins that are required. A tool for fitting them to the board is available, but they can usually be pushed into place quite easily.

CASE

There is potentially some advantage in using a metal case for a sensitive audio project such as this one, because it can help to screen the circuit from stray pickup of electrical noise such as mains "hum". However, a small plastic box should be perfectly all

COMPONENTS

See SHOP TALK page

Resistors

R1	4k7
R2,R3	680Ω (2 off)
R4,R5	39k (2 off)
R6	68k
R7	2k2
R8	330k
R9	560Ω

All 0·25W 5% carbon film

Capacitors

C1	100µ radial elect. 10V
C2	47µ radial elect. 16V
C3	10µ radial elect. 25V
C4	4µ7 radial elect. 50V
C5	1µ radial elect. 50V
C6	220µ radial elect. 10V

Semiconductors

TR1	BC549 *npn* transistor
IC1	LF351N op.amp (see text)

Miscellaneous

MIC1	electret microphone insert (see text)
B1	9V battery (PP3 size)
SK1	3·5mm jack socket (see text)
S1	s.p.s.t. min toggle switch

Small plastic or metal box, approx. 100mm × 75mm × 40mm; 0·1 inch matrix stripboard, measuring 30 holes by 16 strips; battery connector; 8-pin d.i.l. socket; multistrand wire; solder, etc.

Approx. Cost Guidance Only £9 excl. headphones

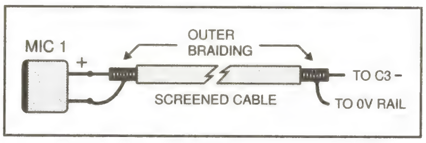


Fig.3. Screened microphone cable must be used if it is more than a few centimetres long.

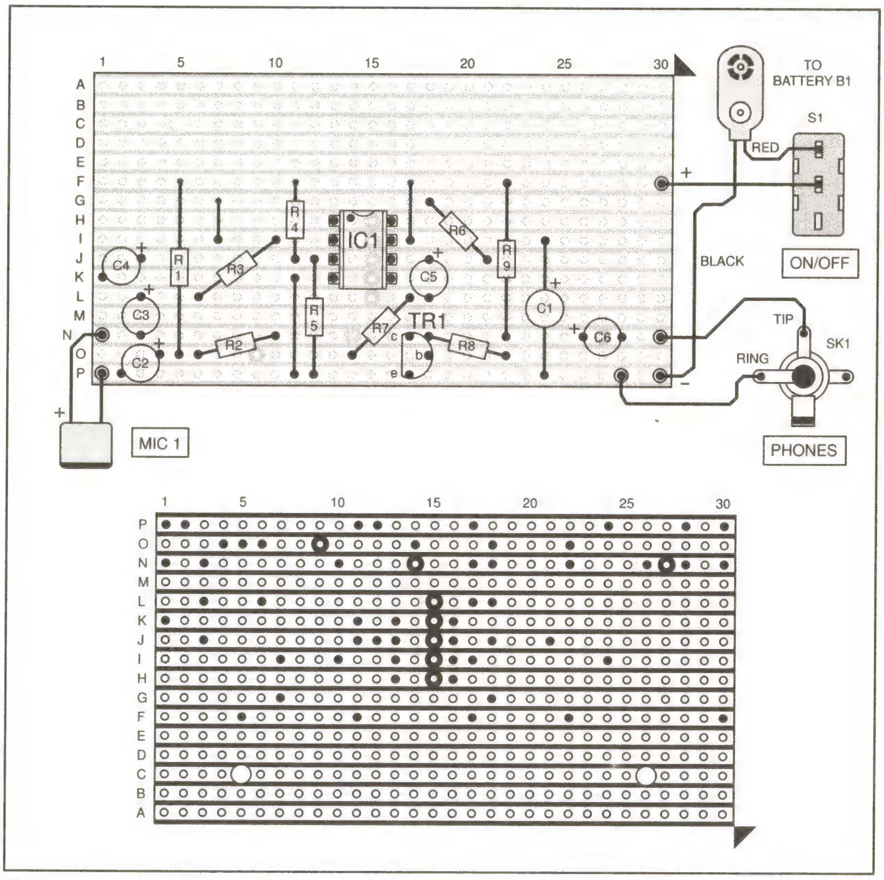
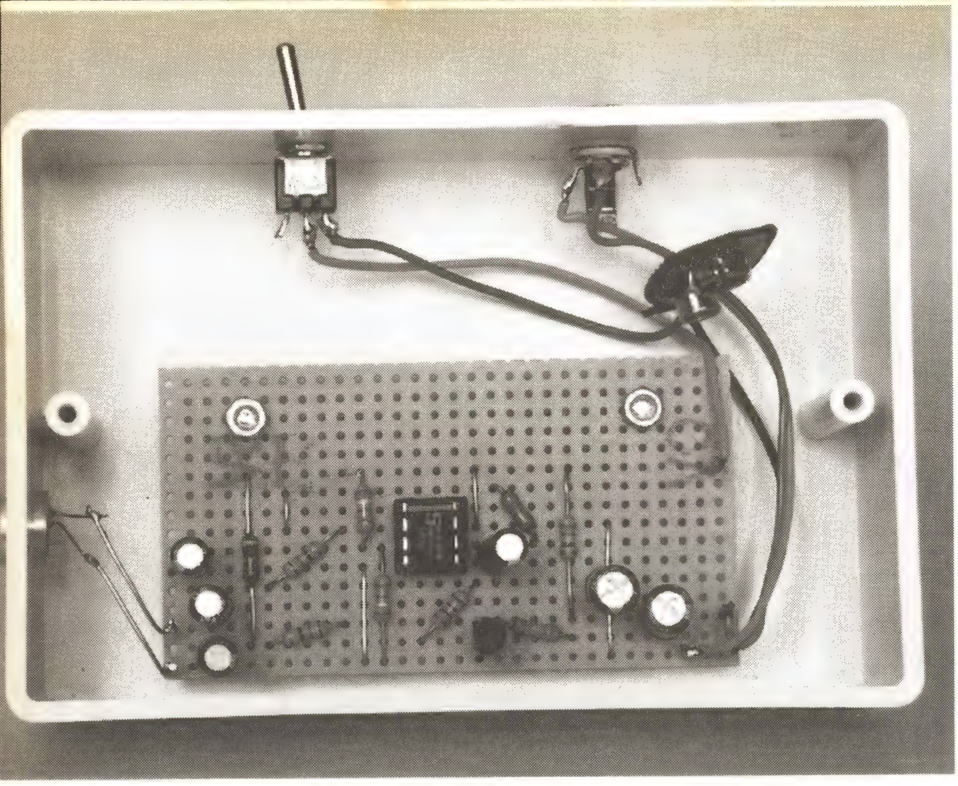


Fig.2. Stripboard component layout, off-board hard wiring and underside view showing breaks required in the copper tracks.



Layout and wiring of components inside the small plastic case, keep the leads to the mic. and 'phone socket well apart.

right unless the unit is likely to be used in an electrically "noisy" environment.

The component panel is bolted in place using metric M3 or 6BA bolts, and it is advisable to use short spacers or some extra nuts between the board and the case. This prevents the board from distorting and possibly cracking when it is bolted in position. The exact layout of the unit is not critical, but try to keep the wiring to MIC1 and SK1 well separated.

The construction diagram Fig.2 shows SK1 as the usual open style 3·5mm jack socket. This is the correct type of socket for use with a crystal earphone, but a 3·5mm stereo jack socket is needed for medium impedance stereo headphones. The two phones must be connected in series, which means that the earth tag is ignored and the connections are made to the other two tags of the socket (either way round).

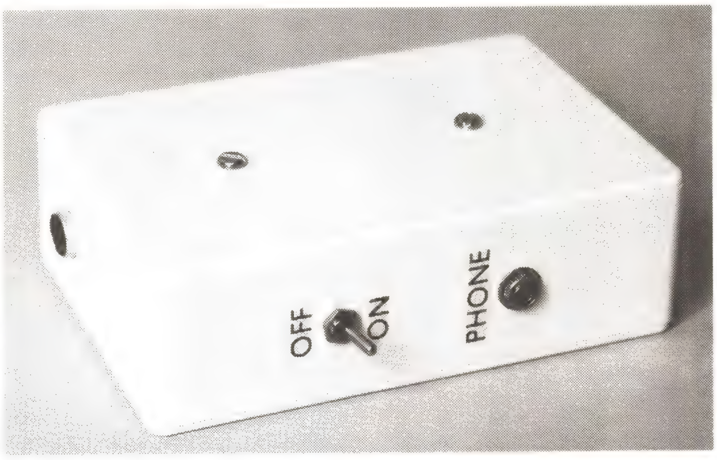
MICROPHONE MOUNTING

The best way of dealing with the microphone depends on the manner in which the unit will be used. In most instances it can simply be mounted at one end of the case.

Probably the easiest way of mounting it is to drill a hole in the case of the same diameter as the insert, and to then glue the insert in this hole. An alternative approach is to mount the microphone insert at the end of a piece of plastic tubing and to mount this tube on the case. An advantage of this method is that it makes it easy to manoeuvre the microphone into awkward places, but it is difficult to produce a strong assembly that will not keep breaking apart.

It is probably more practical to have the microphone insert separate from the main unit and connected to it via a screened lead about 0·5 to 2 metres long. The screen of the cable carries the earth connection, and the inner conductor carries the connection to capacitor C3, as shown in Fig.3.

The microphone insert will only work properly if it is connected with the right polarity. If the polarity is not marked on the unit itself the manufacturers or retailer's literature should provide connection information.



Usually one terminal connects to the metal case of the insert, and this should be the "–" lead that connects to the 0V rail of the circuit. Getting the polarity wrong is unlikely to damage the insert, so if all else fails trial and error can be used to determine the correct method of connection.

SEPARATE MICROPHONE

If a separate microphone is used it is possible to use a "proper" electret type, complete with built-in battery supply. As pointed out previously, R1, R2, and C2 must be omitted if a microphone of this type is used. A "proper" electret microphone should be fitted with a screened lead and a plug. The plug will normally be a 3·5mm or standard (6·35mm) jack plug.

The connections to the circuit board are made via a socket of the appropriate type fitted on the front panel of the case. The unit will not work properly unless this socket is connected the right way round. If there are major problems with stray pickup of mains "hum", etc. the socket is connected the wrong way round.

TESTING

With the headphones or earphone connected and the finished unit switched on it should be obvious if the unit is working correctly. If all is well there will be a noticeable "hissing" sound from the headphones or earphone, and sounds in the room should be heard loud and clear.

If there is a "hissing" sound but no sound pickup whatever, try reversing the connections to the microphone insert. If you are using headphones maintain a reasonable distance between the microphone and the headphones or there could be problems with acoustic feedback. ☐

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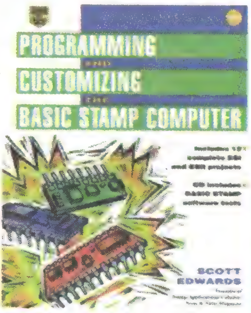
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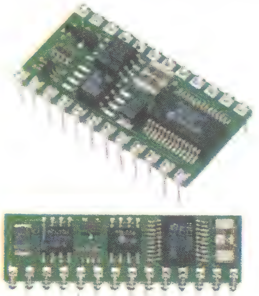

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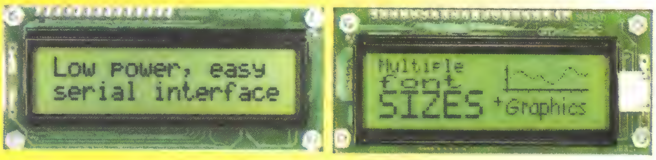

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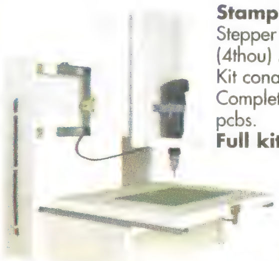

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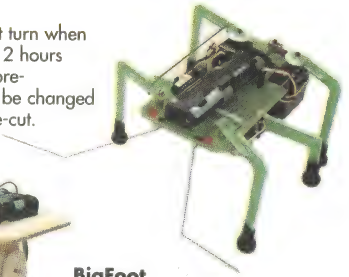

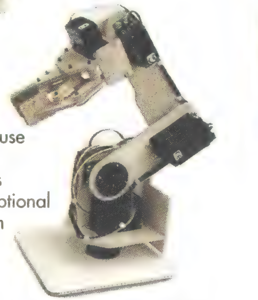

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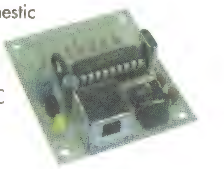
Controlled from PC (Windows freeware provided) or from optional keypad. Stands about 450mm high when fully extended.
Kit includes all pre-cut body parts, servo controller board, servos and software. Requires 9v Dc. Kits start at **£189**

BigFoot
Stamp1 based walking humanoid
Walks forwards/backwards with left and right turn when detects obstacles. Electronics pcb pre-built and tested.
Programme pre-loaded but may be changed with supplied software.
Full kit £68

Alex- Animated Head
Stamp2 based controller with voice record-playback capability, PIR input and/or random playback. 4-servo actions are recorded/edited one track at a time. May also be controlled from PC.
Head kits start at £29. Controllers from £29

On Screen Display
Superimpose text onto standard CCTV from simple RS232 serial line.
Ready built/tested at **£59**

IR Decoder Board
Control your project using a standard domestic IR remote.
7 Output lines (5v @ 20mA) may be set to momentary or toggle action.
Simple teaching routine. Requires 9-12vDC
Supplied built and tested.
£29 single quantity



Servo Driver Board
Control up to 8 standard hobby servos from an RS232 serial data line using this controller board. Simple command structure holds servos in position until update is received.
Fully built and tested- requires 9vDC and servos. Supplied with Windows freeware.
£29 single quantity. Optional keypad available.

Milford Instruments
120 High Street, South Milford, LEEDS LS25 5AQ
Tel: 01977 683665 Fax: 01977 681465

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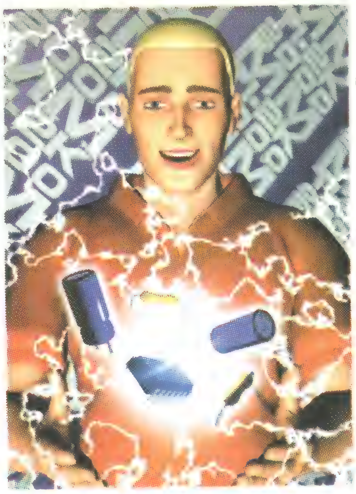
EPE/ETI Tutorial Series

TEACH-IN 2000

Part One – Introduction

JOHN BECKER



What we propose to do during this 10-part *Teach-In 2000* series is to lead you through the fascinating maze of what electronics is all about! We shall assume that you know nothing about the subject, and so shall take individual components and concepts in simple steps and show you, with lots of examples, what you can achieve, and without it taxing your brain too much!

Through these simple steps we hope to prove to you that using electronic components need not be a complex task and that, providing you think about each stage of what you are trying to create, you can actually design and build something that works!

In this Introductory section, we explain our approach to the subject, what things you need to buy, and then lay down a few simple ground rules.

MUCH of electronics is about building blocks, and once you have understood what some of the primary building blocks can do and why they can do it, these blocks can be combined in many different ways to achieve increasingly more sophisticated goals.

To assist you in getting to know about the various building blocks, a set of illustrative computer programs has been prepared. We believe these to be capable of running on any comparatively recent PC-compatible computer (from Windows 3.1 upwards), provided that it can accept a 3·5-inch disk or is capable of downloading the programs from the *EPE* web site. It should have a colour monitor.

SOFT APPROACH

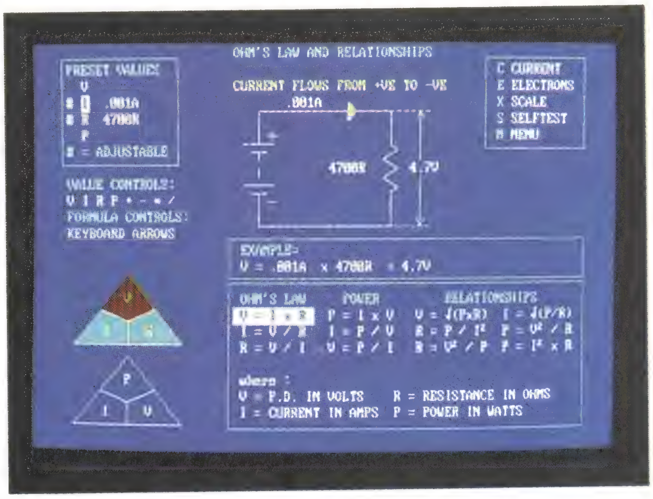
We stress, though, that it is ***not necessary*** to own a computer in order to gain benefit from following this *Teach-In* series. Whilst you will not gain *full* benefit if you don't have a computer, the series is structured so that it can still be studied beneficially without one.

At present, programs are available to accompany the first few parts of this ten part series. Others are in preparation and will be available later on in the series.

The software is available on 3·5-inch disk from the *EPE PCB and Software Service,* see that page in this issue – disk *EPE Teach-In 2000*). The same software may be downloaded free via **ftp://ftp.epemag.wimborne.co.uk** or via **http://www.epemag.wimborne.co.uk**.

To instal the software on your computer, follow the instructions provided with the **TEACH2K.TXT** text file. This can be read using DOS EDIT or through any normal wordprocessing software (including Windows Notepad and Notebook).

The *Teach-In 2000* programs not only illustrate particular electronics concepts discussed in each Tutorial part, but also offer you interactive involvement, with the ability to specify your own component values. Self-test and experimental exercises are included, to really let you get to grips with understanding this fascinating technology.



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OHM'S LAW AND RELATIONSHIPS

PRESET VALUES:                                       C CURRENT
  V               CURRENT FLOWS FROM +VE TO -VE      E ELECTRONS
# I  .001A              .001A                        X SCALE
# R  4700R                                           S SELFTEST
  P                                                  M MENU
# = ADJUSTABLE
                        4700R        4.7V
VALUE CONTROLS:
V I R P + - * /
FORMULA CONTROLS:
KEYBOARD ARROWS

                  EXAMPLE:
                  V = .001A  x 4700R  = 4.7V

                  OHM'S LAW    POWER       RELATIONSHIPS
                  V = I x R    P = I x V   V = √(PxR)   I = √(P/R)
                  I = V / R    I = P / V   R = P / I²   P = V² / R
                  R = V / I    V = P / I   R = V² / P   P = I² x R

                  where :
                  V = P.D. IN VOLTS      R = RESISTANCE IN OHMS
                  I = CURRENT IN AMPS    P = POWER IN WATTS
```

Photo 1.1. Ohm's Law interactive screen (discussed in Part 3).

In future parts, the software will additionally allow you to use your computer as an item of test equipment, allowing you to input data from both analogue and digital circuits, displaying it as meaningful screen data and/or waveforms.

This facility will be of great benefit to you long after you have learned the information offered during the series.

COVERAGE

The subjects to be covered include (amongst other things) facts and equations for using resistors, capacitors, potentiometers, diodes, light emitting diodes, transistors, logic gates, other digital circuits, operational amplifiers, liquid crystal displays, signal waveforms, Ohm's Law and its derivatives, binary and hexadecimal logic, analogue to digital conversion, digital to analogue conversion, computer interfacing, timing calculations, frequency generation, frequency counting, simple audio amplifying, to name but some of the wide array of subjects to be featured.

The series is not directly related to any formal courses or qualifications on electronics, but is based around those subjects which the author has found to be most important during several decades of involvement in electronics, both professionally and as a hobbyist. It should appeal to anyone of any age who wants to get to know what electronics is all about, and to put it to good use.

JUST PLUG IN

The vast majority of the *Teach-In* exercises and experiments are carried out on a plug-in breadboard, and use a 6V battery as the power source. You do not need a soldering iron for the first several parts of *Teach-In*. However, later in the series, some of the circuits discussed will benefit from construction on a printed circuit board allowing their long-term use as items of test equipment. For these constructions a soldering iron will be needed.

Although this *Teach-In* will not instruct you in soldering techniques, we have available the excellent and highly-acclaimed *Basic Soldering Guide* by Alan Winstanley (*EPE*'s equally excellent and highly-acclaimed On-Line Editor!), which will tell you all you need to know – it is obtainable from the Editorial Office and via the *EPE* web site.

WHAT YOU NEED

There are two groups of items you need, comprising hardware and the electronic components themselves. You should get many years of value out of them!

Some of our advertisers are putting together special *Teach-In* packs and readers should browse their adverts and check out the *Shoptalk* page.

WHAT YOU NEED – Basic Items

- Digital multimeter, preferably a good one, but even a cheap one will allow you to perform all the tests we ask you to do during the series. It is recommended that if you can, you should buy one which not only has test *probes*, but also test leads with *clips* on one end, allowing the leads to be clipped onto component wires and legs.

If you cannot obtain clipped leads, you can easily make your own using two 0·5 metre lengths of extra-flexible wire, to which you connect miniature insulated crocodile clips at one end, and 4mm plugs at the other (or to suit meter). The colours should be red and black.

Battery connection leads can be similarly made, to the same length, with insulated crocodile clips at each end.

- Plug-in breadboard, 64 holes long, 14 holes wide, basic hole spacing (pitch) 0·1-inch (2·54mm) – see Photo 1.2.
- Heavy duty 6V (volts) battery, with spring terminals – see Photo 1.2. Do not use any battery that has a different stated voltage (e.g. a 9V battery MUST NOT be used).
- Solid core connecting wire, approx 22 s.w.g. core diameter, one small reel (preferably plastic coated, any colour, but may be "naked").
- Wire cutters (for cutting component leads and connecting wires).
- Wire stripper for small diameter plastic-insulated wires (typically size 1·2mm diameter).
- Small electrical (insulated) screw driver (blade tip about 3mm wide).
- Small thin-nosed pliers, insulated handles.
- Extra-flexible stranded plastic covered wire (approx. 2mm dia.), 2 metres each of red and black (or green).
- Miniature crocodile clips, insulated covering, preferably with screw terminals to which extra-flexible wire can be secured (they will otherwise need soldering), 10 off (some for future use).
- 4mm plugs (optional, see multimeter note above), one each of red and black, preferably with screw terminals.
- 1mm terminal pins, double-sided – a handful (see text).
- 1mm pin headers (say 5 strips, each about 20 pins).
- Miniature soldering iron, mains powered, 15W, bevel tip approx. 3mm wide.
- Solder, multicore, 22s.w.g.

QUANTITIES

The quantities and values of components we suggest are not only so that you can perform the wide variety of experiments that we discuss, but will also result in a good "spares" collection for future long-term use. Go for larger quantities than those given for resistors and capacitors if funds permit (say 10 off each, for example). Where no quantity is stated, only one item is required.

With regard to resistors and capacitors, if you can buy a "bumper bundle" of mixed values do so, but do ensure that they are of reasonable size suited to breadboard use at a minimum of 10 volts (and that they are of good quality). They should include the majority of the values listed (and possibly other values as well). Avoid resistors that are rated for 1 watt or greater since their size may be too great.

Whilst you may not understand the values listed (although you'll soon do so!), your component supplier will if you just present the list to him.

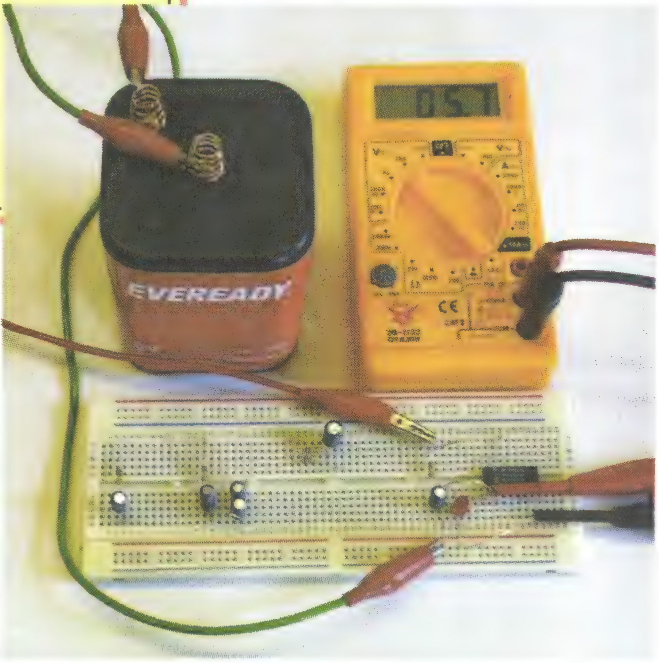


Photo 1.2. Examining one of the breadboard experiments in Part 2.

WHAT YOU NEED – Electronic Components

- **Resistors**

47Ω, 100Ω, 220Ω, 470Ω, 1k, 2k2, 4k7, 10k, 22k, 47k, 100k, 220k, 470k, 1M, 2M2, 4M7, 10M (say 5 off each).

All values rated at 0·25W (or 0·33W) 5% carbon film.

- **Capacitors**

10p, 22p, 47p, 100p, 220p, 470p (say 5 off each).

All miniature polystyrene or ceramic (disc or plate).

1n, 2n, 4n7, 10n, 22n, 47n, 100n, 220n, 470n (say 5 off each). All miniature ceramic (disc or plate).

1μ, 2μ2, 4μ7, 10μ, 22μ, 47μ, 100μ, 220μ, 470μ, 1000μ, 2200μ (say 5 off each up to *100μ*, 2 off each *220μ* and above). All electrolytic, radial mounting.

All capacitors should have a minimum working voltage rating of 10V (a higher voltage rating is acceptable providing the size of the component is not too great – component suppliers' catalogues should quote the physical size of capacitors in relation to their capacitance values and voltage ratings).

- **Preset Potentiometers**

100Ω, 470Ω, 1k, 4k7, 10k, 47k, 100k, 470k, 1M (say 2 off each). Miniature round, enclosed, horizontal, printed circuit board mounting.

- **Control Potentiometers**

100k linear, 100k logarithmic. Panel mounting, "standard" diameter mounting bush and spindle, preferably plastic spindle (without switch).

- **Semiconductors**

Red light emitting diode (l.e.d.), about 5mm diameter (say 10 off)

74HC04 CMOS hex inverter gate (2 off)

74HC14 CMOS hex Schmitt inverter gate (2 off)

- **Miscellaneous**

ORP12 (or NORP12) light dependent resistor (l.d.r.)

10k thermistor (n.t.c. type)

A few other components will be called for in later parts of the series (but not before Part 4). Amongst them will be:

1N4148 signal diode (say 10 off)
1N4001 rectifier diode (say 5 off)
BC549 (or 2N3704) *npn* transistor (say 5 off)
BC559 (or 2N3702) *pnp* transistor (say 5 off)
LM358 dual op.amp (say 3 off)
74HC00 CMOS quad 2-input NAND gate
74HC02 CMOS quad 2-input NOR gate
74HC08 CMOS quad 2-input AND gate
74HC32 CMOS quad 2-input OR gate
74HC86 CMOS quad 2-input XOR gate
74HC4017 CMOS decade counter
74HC4024 CMOS 7-stage binary ripple counter
TLC549 analogue-to-digital converter
DAC0800 digital-to-analogue converter
Miniature active buzzer
Low-cost pair of high impedance personal headphones
Miniature jack socket to suit personal headphones
Miniature electret insert microphone
36-way Centronics female parallel printer port connector (p.c.b. mounting, and for which a p.c.b. will become available)

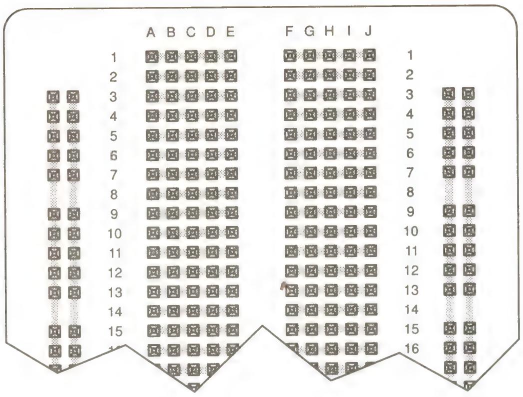


Fig.1.1. Arrangement and interconnection of the breadboard strips. Note that the outer strips between 31 and 34 are not connected.

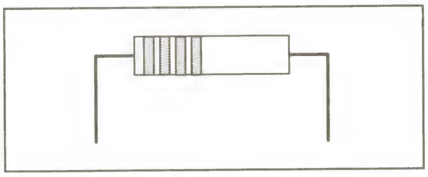


Fig.1.2. Example of trimming and shaping resistor wires to fit into breadboard.

BREADBOARD CONSTRUCTION

You will see that the holes in the breadboard are arranged in groups of five. Beneath the holes are miniature electrical clips. All five clips in a group are electrically connected and all groups are electrically isolated from each other (with the exception of the two parallel strips to either side of the board). The arrangement is shown schematically in Fig.1.1.

Components are plugged into and between the clip groups so that they become inter-connected in a specific electrical configuration, as required so that they perform a particular function when electrical power is applied. Examples are shown in Photo 1.2.

Components are usually supplied with connecting wires that are far longer than required (especially resistors and capacitors). Prior to plugging a component into the breadboard, we suggest that you cut the wires to a length of about 1·5 centimetres away from the component's body.

This should allow you to easily handle the components, yet avoid the possibility of extra long wires adversely touching the leads of other components. The length should also allow test leads to be clipped onto the component wires.

You will need to bend the leads of some components (resistors and diodes in particular) so that they plug into the board. This is illustrated in Fig.1.2. Make the bend just fractionally away from the body of the component, especially the diodes which often have a glass body that may fracture if subjected to stress when leads are bent. Thin-nosed pliers are useful to help form the bend.

Components may also be linked to others using short lengths of the solid-core wire specified earlier (the cut-off wires of components can often be used for the same purpose). Cut the length you need and then trim off the insulation (if present) to a length of about 1cm, using the wire strippers. Thin-nosed pliars can shape the wire as required for plugging in, but you may simply bend the wire by hand if you are just making experimental links.

If you are using uninsulated solid-core wire, ensure that it does not adversely contact other components.

Short lengths of solid-core wire may also be inserted in the board to assist in the connection of power/meter leads and their clips. A better option is to use the double-sided 1mm terminal pins listed earlier.

ELECTRICAL POWER

Two terms that will be used frequently in this series are *voltage* and *current*. Their units of measurement are *volts* and *amps*. Sub-units of measurement are also used, which will be defined in due course.

To explain the nature of electrical power would take us into atomic physics, which we have no intention of exploring. However, we can simply explain the concepts of the terms by using a time-honoured analogy:

Imagine a water tank with a hole in its base. We are sure you know that water will flow out through the hole at a rate depending on the fullness of the tank and the size of the hole.

The greater the pressure of the water, the faster that it will flow through the hole. The pressure depends on the height of the water above the hole. The volume of water that flows through the hole depends on its diameter. In electrical terms, the "height" is expressed in "volts", the volume of flow is expressed in "amps".

There is an allied third term, *watts*, which expresses the amount of *power* that flows in respect of given values for volts and amps (it is the result of the two values multiplied together).

It is important to be aware that electronic components will only accept voltage, current and power flow within specified limits. These limits vary between component types and must not be exceeded (although there is usually a fairly wide margin of excess which they will tolerate for short periods).

All this will become much clearer as we progress through the series. Refer now to the first Tutorial, and let's start exploring electronics!

TEACH-IN 2000 – Tutorial 1

COLOUR CODES AND RESISTORS

RIGHTLY or wrongly, we are going to assume that you don't yet know what component types look like. No doubt we're wrong – but we've got to start somewhere! (And if we are right, you should also page through that excellent little free gift on the front cover of this issue – the *Identifying Electronic Components* booklet.)

Once it's arrived through your letterbox, within that bag of components you've bought for this *Teach-In* series (as recommended in the Introduction) will be some that look like those in Photo 1.3.

The component on the left is a light emitting diode (l.e.d.), a resistor (having four coloured bands) is in the centre. The right-hand component is an electrolytic capacitor (to be discussed in Part 2).

Photo 1.3. Left to right: Light emitting diode, resistor, electrolytic capacitor.

LED BY THE LIGHT

Find a red l.e.d., plus a resistor whose bands are coloured yellow, violet, brown and gold, in that order. Plug them into your breadboard as shown in Fig.1.3, then clip the two power leads to your battery as shown in the Photo 1.4.

You will now see one of two situations – the l.e.d. is glowing nicely ("turned on"), or it is not glowing at all! Disconnect the battery. Now unplug the l.e.d., turn its leads round the other way and plug it back in. Connect the battery again. Whichever case was true first, the opposite should be true now.

This experiment with the l.e.d. is an example of the use of a *semiconductor*, a class of electronic component that has

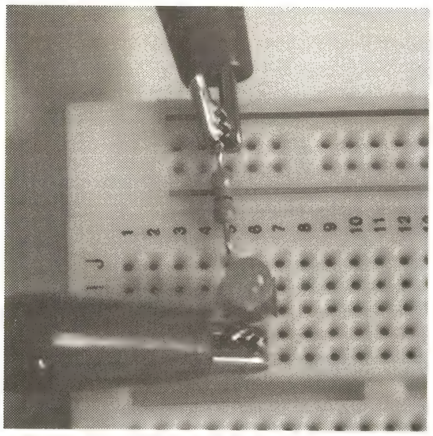


Photo1.4. Power leads clipped to l.e.d. and resistor experiment.

thousands of members in its enormous range of families, and which includes not only such simple items as l.e.d.s, but also the highly sophisticated microprocessor that controls your computer.

What you have been shown is that semiconductors will (normally) only work in a circuit if they are connected to its power supply the correct way round. There are other components, too, which are equally dependent for their correct operation on being connected the "right" way round. We shall say more on this as we progress through the *Teach-In* series.

With the l.e.d. positioned in its "glowing" direction, and with the battery disconnected, unplug the resistor, turn it round and plug it back in. Reconnecting the battery, the l.e.d. should still glow. A simple second lesson, but just as important – resistors are components that are quite content to be connected either way round into a circuit.

What we have also implied through the above examples is that power supplies should always be disconnected or switched off before physical changes are made to any circuit. Always do so, even if we don't actually say so each time a change is suggested.

MARKED DIFFERENCE

Now find a resistor whose bands are brown, black, red and gold, and another whose bands are red, red, brown and gold.

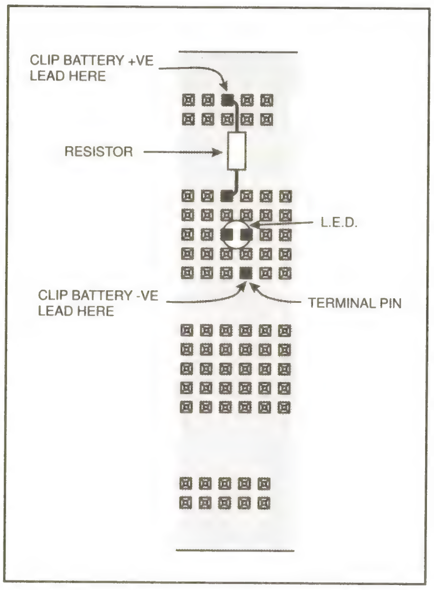


Fig.1.3. Component positions and battery lead connections for the l.e.d. and resistor experiment.

In turn, plug these resistors into the board in place of the original one. What do you observe with each of them? The l.e.d. glows less brightly with the brown, black, red and gold resistor, but glows much more brightly with the red, red, brown and gold one. Now try a brown, black, yellow and gold resistor – no glow at all!

Why the difference in l.e.d. response to components that look the same physically? Well, that is the aim of this *Teach-In* – to tell you about not just resistors, but other important types of component as well, in such a way that you understand how they behave and how you can use them to perform meaningful tasks in circuits of your own invention.

The lesson you should learn from this last experiment is that components may *look* alike, but identifying marks (in this case coloured bands, but may be numbers and letters in other instances) are vitally important – they state a component's "value".

What that information conveys depends on the component type involved, but in the case of resistors (whose nature will be explained more fully later) it states the amount of "resistance" that they offer to electrical current when it flows through them.

Each of the three resistors you've just used have different amounts of resistance, and the colour code, once you know how to read it, tells you that value. The observed response of the l.e.d. depends on the voltage applied to it and the amount of resistance that the voltage has to flow through. We shall presently look at resistors in detail, but first let's examine colour codes.

BASIC COLOUR CODES

Whilst resistors are a prime example of components that are likely to be colour coded, others such as capacitors, diodes, inductors, transformers, ribbon cables, connecting wires, plugs and sockets often use them as well, although perhaps not quite so widely.

Consequently, one of the most important skills that any would-be electronics constructor should acquire is the ability to correctly read colour codes.

First, then, let's help you to become familiar with the basic colour codes and the numbers that they represent. The way in which groups of colours are interpreted on the components themselves will be described when we discuss those items. The 10 basic colours are allocated as in Table 1.1. As we shall reveal later, however, they are not the only colours available, although the remainder are not used in the same way.

Table 1.1. Basic colour codes used in electronics.

Colour	Coded Number
Black	0
Brown	1
Red	2
Orange	3
Yellow	4
Green	5
Blue	6
Violet	7
Grey	8
White	9

We have set up a simple computer program which will help you to learn these colour codes and their values, and to prove to yourself that you do actually remember them.

Run the *Teach-In* software program and select Menu Basic Colour Codes. In the middle of the screen you will see the 10 colour codes, not only numbered and named as in Table 1.1, but also with their colours alongside them. Do be aware, though, that the limits of the computer screen prevent the colours from appearing in exactly the same hues as you might see on actual components.

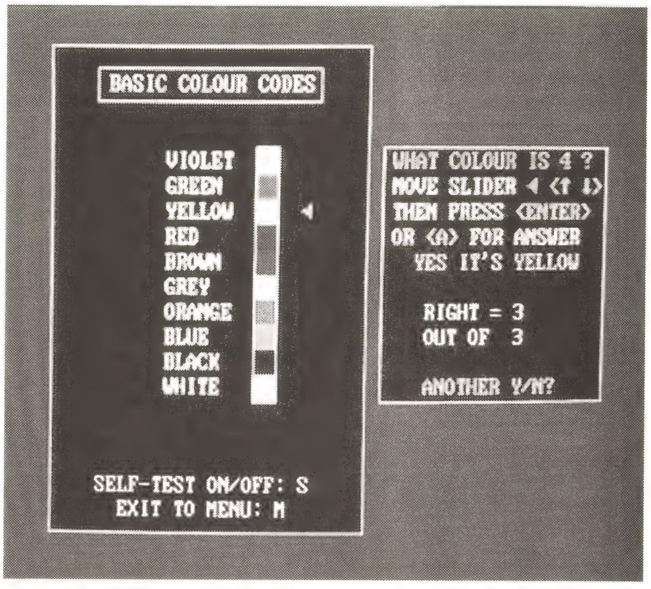
It has to be said, however, that there is no full standardisation on the exact hue that might be printed on components by their manufacturers – they seem to take very wide artistic licence on occasions. It's not uncommon, for instance, that it may be difficult sometimes to differentiate between one manufacturer's red, and another's orange.

However, what you see on the screen (your computer being satisfactorily set-up, of course – and not driving a black and white monitor!), should be sufficient to get you well acquainted with colour codes.

Press <S> to select Self-Test On/Off. A "questions" box appears to the right of the colours display (Photo 1.5), and the colour order in the main box changes and the values disappear. Your task is to use the cursor arrows to select the colour whose number is given in the question.

A random number generator variously selects questions on colours and values. Correct answers earn you points. So give yourself a test!

Pressing <A> provides the answer if you want it, and <S> re-displays the correct



```
BASIC COLOUR CODES

VIOLET
GREEN
YELLOW  ◄
RED
BROWN
GREY
ORANGE
BLUE
BLACK
WHITE

WHAT COLOUR IS 4 ?
MOVE SLIDER ◄ <↑ ↓>
THEN PRESS <ENTER>
OR <A> FOR ANSWER
 YES IT'S YELLOW

  RIGHT = 3
  OUT OF  3

  ANOTHER Y/N?

SELF-TEST ON/OFF: S
 EXIT TO MENU: M
```

Photo 1.5. Section of the computer program display which invites you to test your knowledge of colour codes.

colour code sequence and its numbers. Pressing <M> returns you to the main menu.

RESISTORS

With basic colour codes under your belt (or at least on visual display demand if necessary), let's see how they apply to one particular group of components, resistors.

But, we ask ourselves back at Editorial HQ, do you who are reading this actually know what a resistor is? Perhaps not, even though you've just been using some, so perhaps we should explain matters (and apologise to those of you who do know for taking up your time – but why not read it anyway, you might be reminded of something you've forgotten).

It's inevitable, of course, that in explaining resistors we have to use some terms which you might not be familiar with yet. Such terms will be covered as we progress through the *Teach-In* series, and we expect that eventually you will want to re-read the series from the beginning, at which time things will begin to slot more firmly into place if they haven't already.

BLOW THAT WORM!

Let's give you an analogy about resistance (no, not using water this time). You can be the pushing power instead of the weight of a tank of water.

Take a deep breath and see how easily you can blow it all out again. Not very hard is it? What about if you try to blow it out through a tube, a bit of garden hose? Slightly easier once you've blown out the worms, but still quite hard. Now do it through a drinking straw – really hard, and you probably fail to breath out fully before you need to take another breath.

So what is it that makes the ease of blowing out so different between the three methods? Yes, its the diameter of the hole you are blowing through – big cake hole (!), medium pipe hole (smaller with the worm at home!), small straw hole; and what are the holes doing to the flow of air as you breath out? They are *resisting* it!

In electronics, a similar situation can be said to apply to the way that electrical current flows out from a battery (say) – the amount by which it flows in a given period of time is relative to the "hole size" of the object through which it flows, i.e. to the resistance that the object offers to the electrical current. Although, of course, resistors don't actually have holes in them, unless someone's been malicious!

THE OHMS HAVE IT

As you will discover in due course, everything offers different amounts of resistance to electrical current flow, from almost utterly-totally-nil to almost absolutely-never-to-be-penetrated total refusal.

Any material that *permits* an electrical current to flow through it is known as a *conductor*. But, all conductors, however good, try to resist the electricity flowing through them, in other words, they all have resistance. Even the copper wire which carries electrical current into the appliances in your home has resistance. It may be small when measured on a meter, but it's still there.

Conversely, some materials have a resistance to electrical current flow which is so great that, to all intents and purposes, they can be regarded as non-conductors or insulators, such as rubber and many plastics, for example.

The amount of resistance which a conductor has is expressed as a value in units called *ohms* (in honour of Georg Ohm, a Bavarian pioneer in the investigation of electrical phenomena, born 16-3-1789, died 16-7-1854).

The symbol for ohms as a unit is Greek omega, Ω. However, you may often see capital R used in place of Ω since not all typing equipment can produce an Ω symbol! (Not all computers have the symbol either – the *Teach-In* software uses the term *ohm* (or capital R) rather the symbol Ω to keep it compatible with readers' different system types.)

It might be said that the whole function of electronics as a technology is to control the rate and amount by which electrical current flows from one place to another. Generally speaking, while the current is flowing, it is expected to *actively* do some work: drive the loudspeaker that shatters your hearing, create that enthralling games display on your computer screen, cook your microwave snack for the correct time (sometimes!), and so on.

There are, though, some components which are manufactured to control the electrical flow in a *passive* and far less dramatic fashion. Amongst them are the group which are actually named for their ability to resist the flow, *resistors*. It's astonishing what can be achieved by something that just *resists* when it is used in conjunction with something else that inhibits or encourages electrical flow.

The purpose of resistors, then, is to passively limit or set the flow of current through a particular path in an electrical circuit. It is reasonable to say that, however complex the circuit in which they are used may appear, this is their primary function.

There are many ways in which the attributes of that function can be exploited in conjunction with other components to achieve not only simple results, such as producing a voltage drop at a particular point in a circuit, but also more sophisticated results, such as helping to determine the rate at which some other change occurs.

You will encounter two symbols used in electronics to represent a resistor in circuit diagrams. They are shown in Fig.1.4. The zig-zag symbol is the one on which we at *EPE* have standardised, inheriting it from the original publishers of *EE* and *PE* before the merger, IPC Magazines, who first introduced many of the UK's leading electronics publications. The symbol's history dates well back to earlier years of the 20th Century, and could even be older, maybe Georg Ohm invented it.

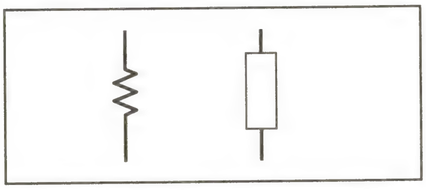


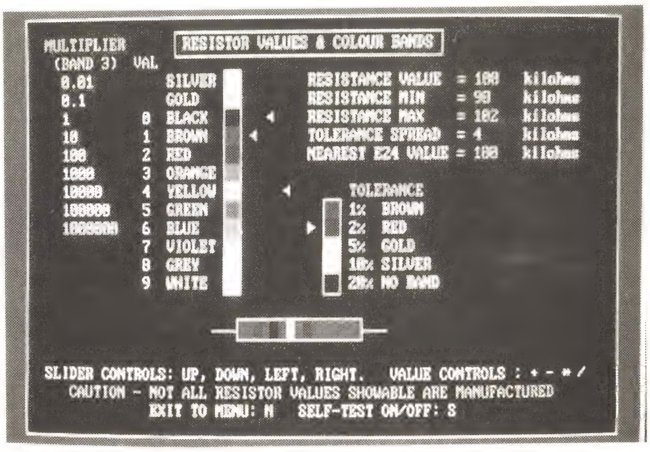
Fig.1.4. The symbols commonly used to represent a resistor.

In circuit diagrams and constructional charts, a resistor's numerical identity is usually prefixed by 'R', e.g. R15.

Since most resistors you are likely to encounter will have their values shown as coloured bands, we'll discuss those next.

RESISTOR COLOUR CODE PROGRAM

We've set up a computer program that illustrates how the values for resistors are expressed in ohms and how those values are shown as colour codes. So, from the software's main menu, select Resistor Values and Colour Codes.



```
MULTIPLIER          RESISTOR VALUES & COLOUR BANDS
 (BAND 3)  VAL
 0.01          SILVER        RESISTANCE VALUE  = 100   kilohms
 0.1           GOLD          RESISTANCE MIN    = 98    kilohms
 1          0  BLACK         RESISTANCE MAX    = 102   kilohms
 10         1  BROWN         TOLERANCE SPREAD  = 4     kilohms
 100        2  RED           NEAREST E24 VALUE = 100   kilohms
 1000       3  ORANGE
 10000      4  YELLOW             TOLERANCE
 100000     5  GREEN              1%   BROWN
 1000000    6  BLUE               2%   RED
            7  VIOLET             5%   GOLD
            8  GREY               10%  SILVER
            9  WHITE              20%  NO BAND

SLIDER CONTROLS: UP, DOWN, LEFT, RIGHT.   VALUE CONTROLS : + - * /
   CAUTION - NOT ALL RESISTOR VALUES SHOWABLE ARE MANUFACTURED
              EXIT TO MENU: M   SELF-TEST ON/OFF: S
```

Photo 1.6. Resistor values and colour codes displayed on the interactive computer screen.

There is a great deal of useful information available to you from this facility. Primarily, you have the main colour codes that you examined (and learned, we hope) in menu selection 1 (see Photo 1.6). Above it are two additional colours which, had the screen been capable of it, would be seen as silver and gold, but we have to make the best of using their names plus colours of grey and yellow to represent them.

Horizontally near the bottom is the representation of a resistor having four colour bands. Looking vertically above these bands you will see four arrows, three pointing left and one pointing right. The arrows point to the same colours that you see in the resistor bands below them. These arrows are under your control using the keyboard cursor keys, up, down, left, right. Try them.

MEET THE BANDS

While moving the arrows, you will see that the details at the top right of the screen change as well. You should begin to recognise a pattern in the Resistance Value number in relation to the arrow positions and associated colour numbers. Let's explain it.

Most resistors which you will be required to use in your early days of learning about electronics are likely to have four coloured bands. The bands are read from left to right, with the resistor facing in the direction as shown on-screen – the colour group to your left. They are named in left to right order as Bands 1, 2, 3 and 4. (Band 4 may be further to the right on some resistors.) Also see Fig.1.5a.

Bands 1 and 2 provide the first two digits of a resistor's value, and Band 3 provides a multiplying value (shown in decimal on the left of the screen) which is applied to the basic value. The number of zeros for each multiplying factor is the same as the number of the colour code that represents it, e.g. blue = six zeros = a multiplying factor of 1000000 (1 million).

You will also notice that there are multipliers of 0·1 and 0·01, represented by gold and silver bands respectively (if only the screen could show it better!).

Resistance values below 1000 are shown in units of ohms, they are then shown in *kilohms* until 1000000, when they are expressed in *megohms*. There is also a third term which you may encounter, *giga* – 1000 million times, e.g. *gigohms*.

While you are using the arrows to get the hang of the colour banding system, also look at the Nearest E24 Value at the top right of the screen. You will see that it does not always follow the Resistance Value answer. This is not because the answer is wrong, but is because that particular value is not manufactured in the range known as the E24 Range (see Panel 1 – Resistance Ranges).

Apart from using the arrows to set the values, there is another way to set them using the arithmetic keys, + – * /. Try them and watch how not only do the numeric values change, but the arrow positions and the coloured bands on the resistor as well.

RESISTOR CODES SELF-TEST

Pressing <S> clears a fair bit information from the screen leaving you with a colour chart, some arrow positions, a coloured resistor and randomly selected questions to answer.

Pressing <A> or <ENTER> provides the answer, <S> returns the full screen information, and <M> returns the main menu.

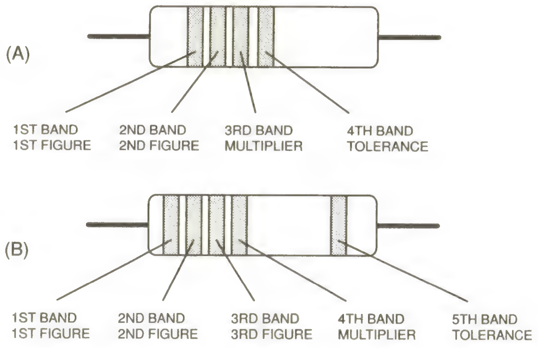
MORE ON RESISTOR CODES

Up to a resistance tolerance of 1% and a power rating of one watt (tolerance is discussed in moment – and power factors another time), resistors are labelled in the colour coded fashion you've just been examining. From 0·5% tolerance and two watts rating, the values are given in figures. There are exceptions to both these conventions.

Many of the colour-coded resistors which you will normally encounter are likely to have a tolerance of 5% or greater (we specified 5% for those you have bought), and will have four coloured bands as we've shown, although the fourth band may be further away from the other bands than is shown on your screen.

As a re-cap away from the computer, the colours used on the four-band resistors we've been discussing are summarised in Table 1.2. The codes have been established by international agreement.

Fig.1.5. Resistors having four coloured bands are those you will normally encounter, but 5-banded resistors also exist.



PANEL 1 – RESISTANCE RANGES

If you count all the E24 answers given by the computer display for all the Resistance Values between, say, 10 and 99, you will find that there are 24 of them, which is what E24 means – 24 values to the multiplier decade.

There are other ranges manufactured as well: E6, E12, E48, E96, for example, each having the number of values per decade as indicated by the "E" value.

Standard resistor values within the ranges may at first sight seem to be strangely numbered. There is, though, a simple logic behind them, and it is to do with the tolerance ranges available.

In fact, there's not really very much to the concept of tolerance: it's just that when anything is manufactured in quantity, it is expensive to ensure that every single aspect of each and every individual is absolutely identical. Nor is it necessary in many applications that absolute identicalness should be achieved – some situations can accept wider variations than others, i.e. they are more *tolerant*. Where a wider tolerance can be accepted, so the manufacturer can produce the product more cheaply.

PERCENTAGES

With resistors, for example, values can be categorised as being within so-many per cent of the nominal value, within ten per cent of it for example, which would be expressed as ±10% (or, somewhat loosely, just as 10%). In other words, a resistor said to be 100 ohms ±10% could have an actual value that is 10% above or 10% below 100 ohms – i.e. from 90 ohms to 110 ohms. A 100 ohms 1% resistor, though, could have an actual value of between 99 ohms and 101 ohms – but it will cost more than the 10% type. As a constructor, you will normally use 5% resistors.

The "E" series values are based on tolerances of ±0·5%, ±1%, ±2%, ±5%, ±10% and ±20%, and are respectively known as the E192, E96, E48, E24, E12 and E6 series, the number indicating the quantity of values in that series. Thus, if resistors have a value tolerance of 5%, for example, a series of 24 values can be assigned to a single decade multiple (e.g. values from 1 to 9, or 10 to 99, or 100 to 999 etc.) knowing that the possible extreme values of each resistor overlap the extreme values of adjacent resistors in the same series.

Work it out for yourself for the following 24 values which comprise the E24 (5%) series:

1·0, 1·1, 1·2, 1·3, 1·5, 1·6, 1·8, 2·0, 2·2, 2·4, 2·7, 3·0, 3·3, 3·6, 3·9, 4·3, 4·7, 5·1, 5·6, 6·2, 6·8, 7·5, 8·2, 9·1

You probably noticed a sequence like this when using the arrows and other controls on the screen.

As another example, the E6 (20%) series simply has six values, as follows:

1·0, 1·5, 2·2, 3·3, 4·7, 6·8

Any of the numbers in an E series can be applied to any decade multiple set. Thus, for instance, multiplying 2·2 by each decade multiple (1, 10, 100, 1000 etc.) produces values of:

2·2 (2Ω2), 22, 220, 2200 (2k2), 22000 (22k), 220000 (220k), 2200000 (2M2)

WITHOUT A POINT

Note an interesting point about the alternative way of expressing the decimal point for some of these numbers, as shown in brackets: the use of Ω, k and M. This is another answer to a typing problem! The decimal point in a number may not always be printed clearly, and the alternative display method is intended to help avoid misinterpretation of component values in circuit diagrams and parts lists (and on the components themselves when colour coding is not used).

These value series apply not only to resistors, but to capacitors and inductors as well. For the latter components, μ (micro), n (nano), p (pico) may be used in place of the decimal point, e.g. 2μ2, 2n2, 2p2.

DISPLAY RANGE

Now you will understand why the E24 value on your computer display does not necessarily tie in with the Resistance Value. We could have programmed the software for other ranges too but, frankly, for most of what you are likely to design or construct, the E24 series is going to be the principal one you use. As far as this *Teach-In* is concerned, we specified resistors having only three values to the decade, 1, 2·2, 4·7. This was to keep down the cost, but other values will find their uses in other applications.

You should now also understand the other three (middle) lines of the top right group in the computer display for resistor values – Resistance Min-Max and Spread. The use of arrow 4 should now be apparent, it lets the program select and calculate the tolerance factors without you troubling your pocket calculator.

Table 1.2. Colour codes for resistors

Colour	Figure	Multiplier	Tolerance
Silver	–	0·01Ω	10%
Gold	–	0·1Ω	5%
Black	0	1Ω	–
Brown	1	10Ω	1%
Red	2	100Ω	2%
Orange	3	1kΩ	–
Yellow	4	10kΩ	–
Green	5	100kΩ	0·5%
Blue	6	1MΩ	0·25%
Violet	7	10MΩ	0·1%
Grey	8	100MΩ	–
White	9	–	–

Life can get a bit more complicated though – colour coded resistors of 2% or less may have more than four bands, such as the example shown in Fig.1.5b. So let's briefly compare the way in which four and five banded resistors are "decoded".

Noting the way in which the resistors are shown in Fig.1.5a, and reading from left to right, the four band example is interpreted as:

Band 1: brown = 1
Band 2: black = 0
Band 3: red = 2 ($10^2 = 100$)
Band 4: gold = 5

indicating a resistor whose value is $10 \times 10^2 = 1000$ = 1kΩ, with a tolerance factor of 5%.

The five band example is interpreted as:

Band 1: red = 2
Band 2: yellow = 4
Band 3: black = 0
Band 4: black = 0 ($10^0 = 1$)
Band 5: red = 2

indicating a resistor whose value is 240×10^0 = 240Ω, with a tolerance factor of 2%.

Examples of the way in which resistors have their value printed on them in figures instead of colours are given in Table 1.3, which shows the internationally recognised coding.

Observe in Table 1.3a how the decimal point is expressed, that the ohm symbol is shown as an R, and that 1000 is shown as a capital K. Note that although capital K is commonly used in circuit diagrams and parts lists to mean 1000 ohms, lower case k is generally to be preferred since capital K has widely become used in computing to mean 1024 (2^{10}, which has significance as a 'round' binary number (10000000000). Binary numbers will be discussed (and actively illustrated on the computer) in a future part of *Teach-In*.

Table 1.3a. Example labelling of resistors in figures.

Figure		Code
0·10	Ω	R10
0·33	Ω	R33
1·0	Ω	1R0
1·33	Ω	1R33
10·1	Ω	10R1
100	Ω	100R
1	kΩ	1K0
10	kΩ	10K
100	kΩ	100K
1·0	MΩ	1M0
10	MΩ	10M
100	MΩ	100M
1	GΩ	1G0

PANEL 2 – RESISTOR FACTS

In manufacturers' data sheets, several parameters will be quoted about the nature of a particular type of resistor. One factor which will be specified is the material from which it is made, i.e. whether it is made from carbon, or a ceramic material, or a metal oxide or even made from wire wound around its body.

The principal parameters for a resistor are:

- Resistance value, which may be expressed in ohms (Ω), thousands of ohms (kilohms or just kΩ, or sometimes KΩ) or millions of ohms (megohms or MΩ)
- Power rating in watts (W)
- Resistance tolerance, expressed as a percentage of its set value, e.g. ±5%
- Temperature coefficient, expressed as the amount by which the set value will change with temperature, variously expressed as parts per million (ppm) or percentage change per degree Celsius (%/°C).

The significance of a resistor's power rating and temperature coefficient will be discussed in another part of *Teach-In*.

Some common types of resistor are:

- Carbon film/ceramic: normal requirements
- Carbon film/ceramic: increased demands
- Carbon film/ceramic: precision resistors
- Carbon film/ceramic: low drift/high reliability
- Metal oxide film: heat resistant to 175°C
- Wire-wound: different constructions for high loads and specialised applications

Carbon film resistors are those you are most likely to encounter in constructional projects, although metal oxide are not uncommon.

Resistors are available as individual components and also as resistor modules in which several resistors are enclosed in a single package, with the connecting pins arranged either as single-in-line (s.i.l.) or dual-in-line (d.i.l.) configurations (the latter look similar to integrated circuits – discussed in other parts of this series). The internal arrangement of the resistors within the module may be several individual resistors, or a network configuration, as shown here.

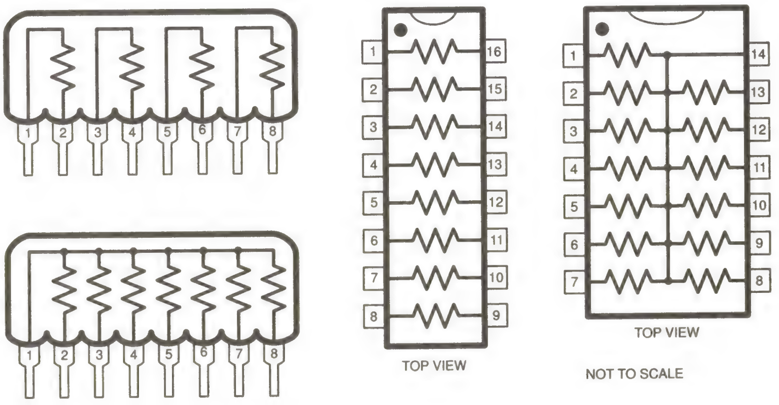


Table 1.3b. A further letter is then appended to indicate the tolerance.

Letter	Tolerance
F	±1%
G	±2%
J	±5%
K	±10%
M	±20%

RESISTOR QUALITIES

You have discovered that resistors allow current to flow in either direction and offer the same amount of resistance to it in which ever direction it flows. In other words, its resistance value is supposedly fixed during manufacture – within the tolerance factor discussed in Panel 1.

However, this "fixedness" is not an absolute value true at all times and in all situations. It is a value that exists only under a given set of circumstances. Internal and external factors can affect the actual value of a resistor, such as the amount of heat to which it is subjected, for example.

The way in which a resistor varies its "nominal" value depends on how it is manufactured, some information on which is given in Panel 2.

OTHER RESISTIVE COMPONENTS

We commented earlier that everything in nature has varying degrees of resistance to an electrical current, from practically nil to practically infinite. The resistors we have been discussing are just one class of component whose basic resistance is pretty well fixed. Not surprisingly, this class is more strictly referred as "fixed resistors".

There several other classes of resistive component, however, whose nature will be discussed in future parts of *Teach-In*. They include components whose resistance changes in response light level, temperature, voltage, humidity and pressure, and are known as *sensor resistors*.

Another group provides variable resistance according to the position of a movable contact. These components are usually known as *potentiometers*.

For this month, though, we've come to end of Tutorial 1. But we hope you will now turn to the Experimental article.

Next month we introduce you to capacitors, and what happens when they are connected to resistors – it's all to do with timing.

TEACH-IN 2000 – Experimental 1

MEASURING AND CALCULATING RESISTANCE

In the Introduction to this *Teach-In*, we said that you should acquire a digital multimeter. Here's your first opportunity to put it to use – measuring resistance.

Plug the black lead into the socket marked COM, and the red lead into the V-OHMS socket, and switch on. Switch to the highest OHMS range and clip the leads to either side of one of your resistors selected at random.

Now switch the OHMS range until a sensible-looking reading is shown on the meter's display. How does this value compare to that indicated by the colour code on the resistor?

Express the difference between the actual reading and the coded value as a percentage, and satisfy yourself that the value is within the tolerance indicated by the tolerance band on the resistor.

Refer back to the Colour Codes program if you've forgotten how the codes are interpreted.

Also satisfy yourself that you get the same reading whichever way round you connect the probes.

What you may find, however (and interestingly), is that the decimal places of the value may change if the temperature of the resistor changes between the readings. Try warming the resistor by holding its body in your fingers between one reading and another.

Check out a few more resistors for their coded and actual values. Indeed, if you've bought the mixed selection bag of resistors suggested in the Introduction, take this opportunity to sort the them. Small press-to-close clear polythene bags are ideal to keep them in once categorised, with self-adhesive labels stating the enclosed value (the coded value, not the meter-read value).

You will thank yourself later for taking this trouble now. The sorting will also help to reinforce your immediate recognition of a resistor's value from its colour code. It soon becomes instinctive for most common values (and what are common values? you may ask – that too you will soon get to know).

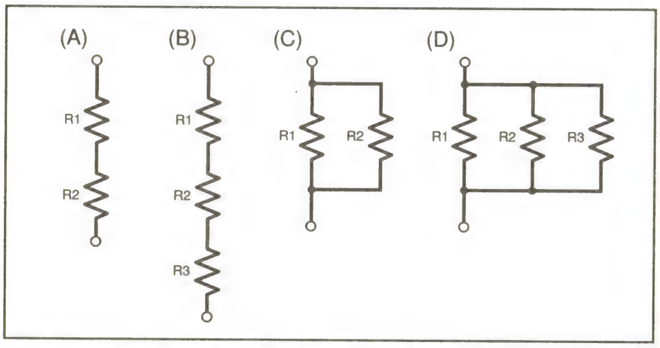


Fig.1.6. Examples of resistors in series (a and b) and in parallel (c and d).

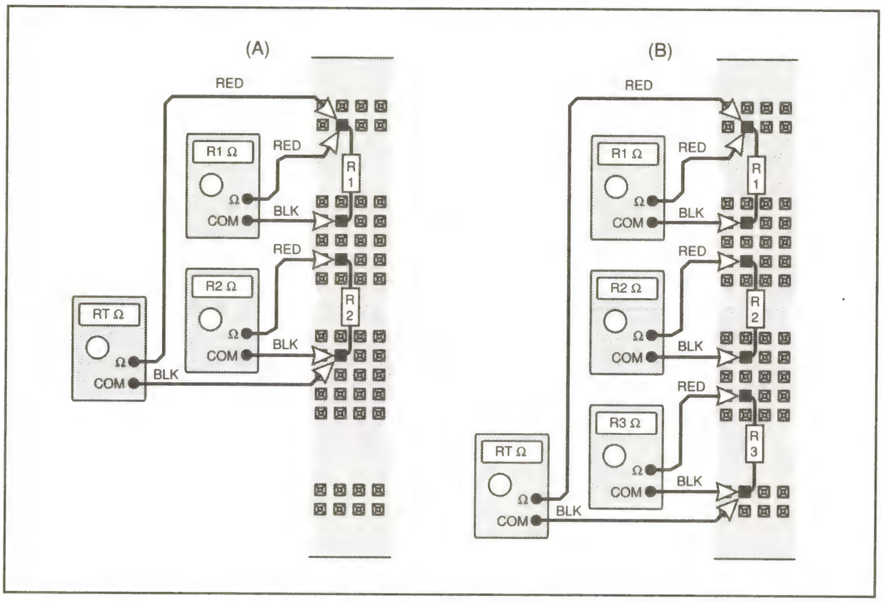


Fig.1.7. Measuring the resistances of two (a) and three (b) serially-connected resistors.

RESISTORS IN SERIES

Two terms you will frequently encounter are *serial* and *parallel*. They describe how two or more components are joined together. Serial connection means a chain of components joined as shown in Fig.1.6a and Fig.1.6b. Parallel connection refers to the configuration in Fig.1.6c and Fig.1.6d.

It is frequently necessary to connect resistors together for a variety of reasons, and to be able to calculate a number of values that result from that connection. Let's take two resistors in series and see what we can establish from them. Select any two resistors of roughly adjacent values, e.g. 47kΩ and 100kΩ (call them R1 and R2), and plug them into your breadboard as shown in Fig.1.7a.

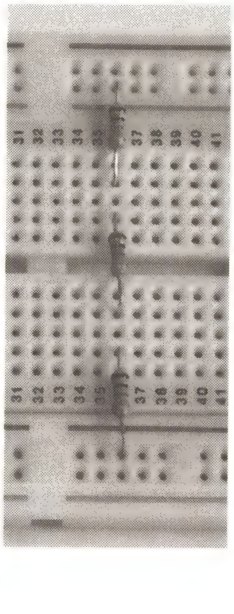


Photo 1.7. Three resistors in series on the breadboard.

First measure the actual resistance of each resistor in turn, making a note of it. Then connect your meter probes to either end of the chain and note the reading. Add the two individual readings together and compare to the reading across the whole chain. How do the two results compare?

Yes, they are equal (within the accuracy with which you actually took the readings).

Add another resistor (call it R3) to the chain as shown in Fig.1.7b, another 100kΩ, for example. Measure the resistance across R3 and note it. Then measure the resistance across the whole chain. Now add the individual values of all three resistors together and compare with the total chain value. Yes, again the two are identical.

From this we can say that the total resistance across any quantity of resistors in series is equal to the sum of their individual values. In other words we can say that:

Total resistance = R1+R2+R3 . . . etc.

POTENTIAL DIVIDER

Let's now put battery power across some resistors in series and see what voltage we can find at their junctions. This configuration is known as a *potential divider*, because the potential (battery voltage in this case) is being divided by the resistors to produce the voltage at their junction.

For starters, we'll examine two 10 kilohm resistors in series. Connect them and your 6V battery as shown in Fig.1.8a. The equivalent circuit diagram is shown in Fig.1.9. Insert 1mm pins (or short lengths of solid-core wire) into the positions shown in Fig.1.8 for the power connections, and then clip the power leads to these pins.

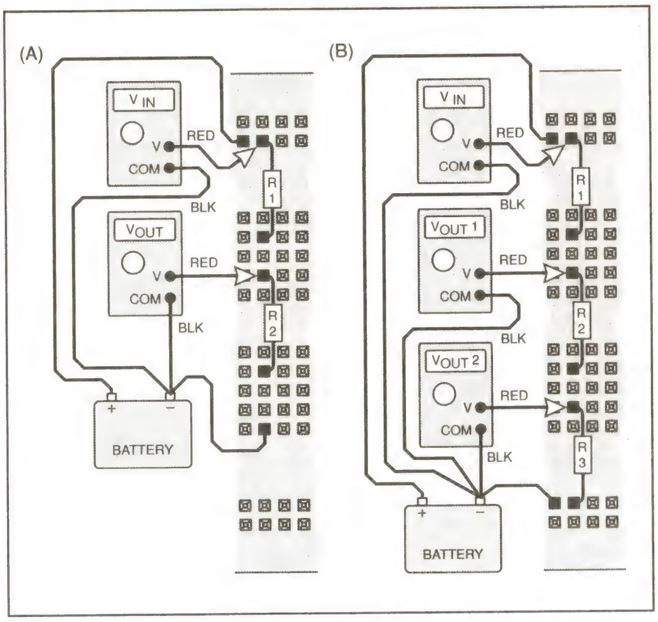


Fig.1.8. Measuring the voltages across two (a) and three (b) resistors in series.

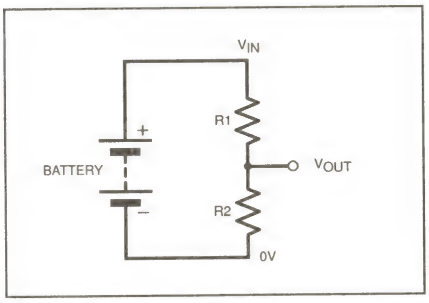


Fig.1.9. Equivalent circuit for two resistors in series across a power supply.

Switch your meter to the first range above 6V d.c. With the black lead on the battery's "–" (negative) terminal (call this point 0V – "nought-V") and the red one on its "+" (positive) terminal (call this point Vin – "V-in"), measure the actual voltage being supplied by the battery. For this discussion we will assume that it is exactly 6V.

With the black lead still on "–", touch the red lead to the junction of the two resistors (call this junction Vout – V-out"). What voltage do you read at Vout? It should be half the battery voltage, 3V. Does this surprise you? It shouldn't because the reason is perfectly logical.

The two resistors have the same value and so the voltage drops equally across both of them. Vout is therefore half of Vin. This fact is true whenever two resistors of the same value are connected in series across a power supply. Substitute any other two resistors of the same value (say two 47 kilohm resistors) for the two 10 kilohm ones and check this out. Try it for other pairs as well.

RATIOS

What happens, though, when two resistors in a chain do not have the same value? Well, it's just a matter of ratios:

Referring to Fig.1.9, you take the value of the total resistance across both resistors (R1+R2), divide this value into that of the resistor at the bottom of the chain (R2), and then multiply the answer by the total voltage across both resistors (Vin). In other words, and referring to Fig.1.9, the calculation required can be summarised as:

$$Vout = R2/(R1+R2) \times Vin$$

In Fig.1.9, let's say R1 is 100kΩ and R2 is 47kΩ. The total resistance of R1+R2 is 147kΩ, call it RT. We know that the battery voltage (Vin) is 6V, so we can say that the voltage at Vout can be expressed as:

$$Vout = R2/RT \times Vin$$

Substituting the known values, we get:

$$Vout = 47k\Omega/147k\Omega \times 6V = 1{\cdot}918367V$$

which is near enough equal to 1·9V.

With R1 and R2 (at the new values) inserted into your breadboard as shown in Fig.1.8a, check this out with your meter.

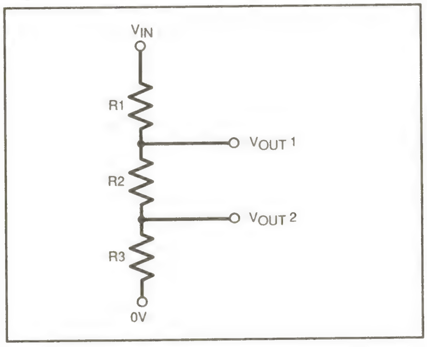


Fig.1.10. Equivalent circuit for three resistors in series across a power supply.

Supposing, though, you had three resistors in series, as in Fig.1.10, how do you calculate the voltages at junctions Vout1 and Vout2. Well, again it's very simple: RT becomes R1+R2+R3 and you write the formulae to read:

$$Vout1 = (R2+R3)/RT \times Vin$$
$$Vout2 = R3/RT \times Vin$$

or just:

$$Vout = Rx/RT \times Vin$$

where Rx is the total resistance of all the resistors in series below the junction whose voltage (Vout) you need to know. Check this out with any three resistors in your breadboard as in Fig.1.8.

We expect you will appreciate that this principle can be applied to any number of resistors in a serial chain – which observation suggests another experiment for you:

Chain as many resistors of whatever value you like and connect the battery across them. Now calculate the voltages you expect to find at each junction, and then use your meter to check the actual voltage against your calculation. (There is, though, a cautionary note presently – Meter Resistance – about the meter itself actually affecting the accuracy of the readings. If your voltage readings are not quite what you calculate, it may be the meter to blame, not your brains!)

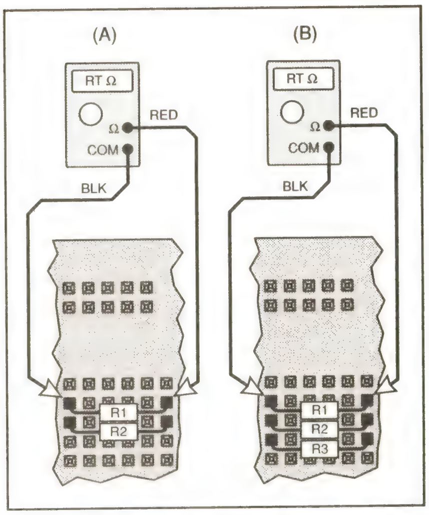


Fig.1.11 Measuring the resistance of two (a) and three (b) resistors in parallel.

RESISTORS IN PARALLEL

Look back at Fig.1.6 where examples of resistors in parallel are shown (Fig.1.6c and Fig.1.6d). That's what we shall discuss now. Connect two 10kΩ resistors (R1, R2) into your breadboard as shown in Fig.1.11. What do you think is the total resistance that your meter will show when connected across them?

Hopefully, you'll respond in a flash: "half of 10kΩ"! Yes, of course it is, it's 5kΩ – prove it on your meter's ohms scale. Any two equal value resistances in parallel will have a total resistance of half the value of one of them.

What, though, if two parallel resistors have different values? Sad to say, it now becomes a bit more complex, but not a lot! There is a simple formula that expresses the way to do it:

$$RT = 1/(Rx1+Rx2)$$

where $Rx1 = 1/R1$ and $Rx2 = 1/R2$.

Such calculations, of course, really need your calculator to work out the one-divide-by bits. But if you take it in small steps it's quite straight forward, even if a bit tedious.

First, let's prove the formula using two equal value resistors, the two 10kΩ just mentioned (remember that 10kΩ actually means 10000Ω):

For R1, $Rx1 = 1/R1 = 1/10000 = 0{\cdot}0001$

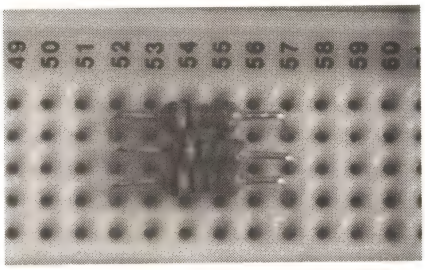


Photo 1.8. Breadboard with three resistors in parallel.

We know that R2 = R1, therefore Rx2 = 0·0001.

Add Rx1+Rx2 (= 0·0002) to produce an intermediate answer (call it Ry).

Now RT = 1/Ry = 1/0·0002 = 5000 = 5kΩ. Point proved!

Now try it for R1 = 100kΩ and R2 = 47kΩ. Do you get answer of 31·97279kΩ (or very close to it)? Good, you've got it!

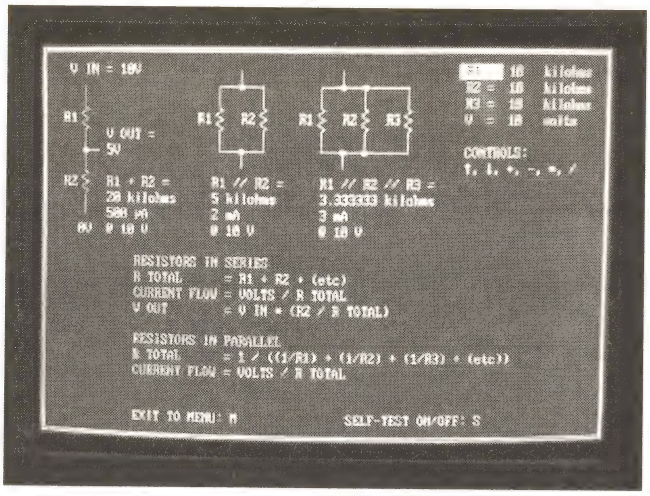
Right then, next stage – more resistors in parallel. Easy, you just extend the formula:

RT =
1/((1/R1)+(1/R2)+(1/R3)+(etc))

Let's try you with three resistors in parallel: 100kΩ, 47kΩ and 10kΩ. If you get an answer of 7·617504kΩ (or very close to it) then you really have understood. Try this out with the resistors in your breadboard as shown in Fig.1.11 and Photo 1.8.

You will have noticed that twice we've said "or very close to it". Different calculators may well give slightly different numbers for the final decimal places – this is quite normal and, generally speaking, of little consequence. In many instances, all you may really need to know is the answer rounded to two decimal places (even fewer on occasions!).

The answers we've given were calculated by our *Teach-In* software. Run it and select menu option Resistors in Series and Parallel. This program illustrates examples of resistors in series and parallel, plus formulae, and the option to change the values allocated to the resistors, see Photo 1.9.



```
V IN = 10V                                              R1 = 10  kilohms
                                                        R2 = 10  kilohms
R1                 R1   R2         R1   R2   R3         R3 = 10  kilohms
     V OUT =                                            V  = 10  volts
     5V
                                                        CONTROLS:
                                                        ↑, ↓, +, -, *, /
R2   R1 + R2 =     R1 // R2 =      R1 // R2 // R3 =
     20 kilohms    5 kilohms       3.333333 kilohms
     500 µA        2 mA            3 mA
0V   @ 10 V        @ 10 V          @ 10 V

     RESISTORS IN SERIES
     R TOTAL      = R1 + R2 + (etc)
     CURRENT FLOW = VOLTS / R TOTAL
     V OUT        = V IN * (R2 / R TOTAL)

     RESISTORS IN PARALLEL
     R TOTAL      = 1 / ((1/R1) + (1/R2) + (1/R3) + (etc))
     CURRENT FLOW = VOLTS / R TOTAL

     EXIT TO MENU: M                    SELF-TEST ON/OFF: S
```

Photo 1.9. Resistors in series and parallel, with calculations, displayed on the interactive computer screen.

At the top right you will see R1 highlighted. Its value can be changed by use of the arithmetic keys (+ – * /) on your keyboard – try them. Then use the up/down arrow keys to change the highlight to one of the other three options, R2, R3 and V.

When highlighted, any option's value can changed. Resistor values are those from the E24 series from 1 ohm to 1 gigohm (1000 megohms). The <+> and <–> keys step up and down in single E24 values, <*> and </> keys step up and down in decade multiples.

The volts range is from 1V to 10V, always in steps of 1V which ever arithmetic key is pressed.

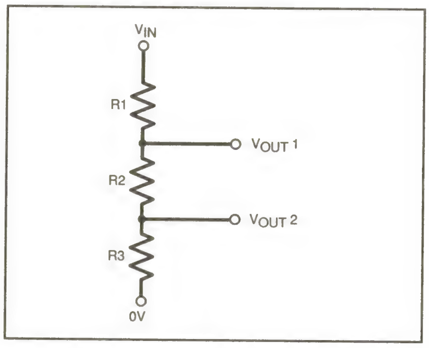


Fig.1.12. Why a meter (represented by resistance R_M) affects the voltage reading at resistor junctions.

You will notice that whenever any value is changed, the formulae are recalculated for that new value. Note that answers may sometimes be expressed with an ending such as E–02. This simply means that the preceding value has to be multiplied by 10^{-2}. For example 4·678013E–02V = $4{\cdot}678013^{-2}$ = 0·04678013V.

You will notice that current flow values are also shown. They will be discussed on another occasion.

Ah, and now you've spotted that enticing Seft-Test option! Press <S> to enter it.

There's little to say about what you now see on the screen – except that you need to follow the instructions that have appeared. On a random basis, the computer selects the questions it wants you to answer. They are all to do with what you have been told about resistors in serial and parallel.

You select the value for the resistors in question, calculate your answer and then tell the computer to show the answer it has calculated. Your aim, of course, is to achieve the same answer. In practice, your answer may be slightly different from the computer's for the final decimal places, for the reason discussed earlier.

It is for this reason that you are not asked to key-in your answer for it to be checked by the computer, with points being awarded accordingly.

When you've tested yourself as much as you want, press <S> to return to the previous full-data screen, or <M> to return to the main menu.

METER RESISTANCE

Just one final point: when measuring the voltage at serial resistor junctions, the resistance of the meter itself can affect the reading in some situations (see Fig.1.12). The meter's resistance (Rm) is seen by the serial circuit as resistance in parallel with that below the junction (R2), and the junction voltage falls accordingly. This effect will be most obvious when high values of resistance form the chain. Note that ordinary analogue meters have a much lower internal resistance than the digital type which (we hope) you are using.

Why not check out your meter now? Connect two 10MΩ resistors in series across your 6V supply. If your meter were perfect and had absolutely infinite resistance, you would normally expect to see exactly 3V at the junction of two (exactly) 10MΩ resistors in series across (exactly) 6V. What voltage reading do you see on your meter? Can you work out its resistance from this reading? We shall refer to this matter again in *Teach-In* Part 2.

We'll have more *Teach-In* intriguements next month – join us!

ACKNOWLEDGEMENT

The author expresses his gratitude to Magenta Electronics for generously providing him with breadboards for this series.

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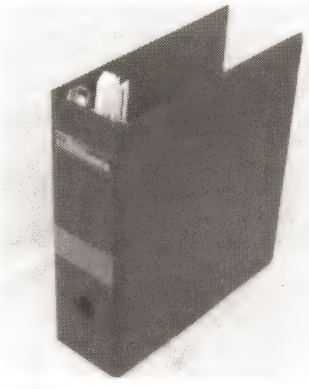

SHOP TALK

with David Barrington

Vibralarm

The main cause for concern when collecting together the parts needed for the *Vibralarm* project will be a source for the delicate bi-morph vibration sensor. This is a piezo ceramic element and was purchased from **Electromail** (☎ ***01536 204555*** or RS ***http://rswww.com***), quote code 285-784. The lowest order quantity listed is 5 off (£1.45 each). Being such a fragile element, it may not be such an expensive investment!

Next on the list of "hard-to-find" are the resistors. The 100 megohm (100M) cermet film fixed resistor and the 10M preset potentiometer also came from the above company; quote codes 158-222 and 387-048 respectively.

Instead of a single 100M resistor, you could use three 33 megohm "high voltage" resistors from **Maplin**, code V33M. These would need to be connected in series, zig-zag fashion, and the remaining two ends soldered to the R2 pads on the p.c.b. The micro piezo siren used in the model was also obtained from Maplin, code JK42V.

Once again, Electromail was the source for the low-current, low-power, low-noise Zener diode, code 184-6661. If a different Zener is used, you will need to check the stabilisation and possibly reduce the value of R1 as outlined in the setting-up procedure.

The "double" printed circuit board is available from the *EPE PCB Service*, code 230 (see page 852).

Acoustic Probe – Starter Project

We do not expect any component buying problems to be encountered by constructors of the *Acoustic Probe*, this month's "starter project" for the novice.

If readers do experience any difficulties in locating a suitable microphone insert through their local supplier, **Maplin** certainly list two. Quote either EM-60B sub-min. code FS43W or EM-10B ultra-min. code QY62S.

The LF351N op.amp gives quite a good signal/noise ratio and is fairly inexpensive. However, if you are looking for enhanced performance, you could try using a high quality audio op.amp such as the NE5534AN. This should provide a significant improvement in the signal-to-noise aspect and extend the probe's capabilities. Most of our components advertisers should be able to supply either of these op.amp i.c.s.

You can use either a crystal earphone (preferred) or *medium* impedance headphones of the type sold as replacements for use with personal stereo units. The circuit is unlikely to give worthwhile results with low impedance types.

Finally, as you will need to trim the stripboard to size, we suggest you go for a fairly large piece so that the off-cut can be used for another project.

Demister One-Shot

Not too much can go wrong, we hope, when searching for components for the *Demister One-Shot* project. However, before undertaking this project, you should first check whether you may be infringing your warranty rights if you tap into your vehicle wiring.

The special U6047B automotive-type timer i.c. was obtained from **Maplin**, code AH44X. They also supplied the heavy-duty 12V relay, with 16A rated contacts (code JM26D) and the small "axial lead" 1A fuse, code DA53H.

The printed circuit board is available from the *EPE PCB Service*, code 245. We strongly recommend that the p.c.b. is mounted in the case using nylon nuts and bolts and you *must* use auto-type wire and connectors where specified.

Ginormous Stopwatch

As the *Ginormous Stopwatch* project originated from Australia, we thought we were going to have problems sourcing components. But thanks to the efforts of Ned, the author, it has not been too dramatic an experience.

Starting with the u.h.f. modules, these are listed by **Maplin** (***www.maplin.co.uk***) and carry the following order codes: u.h.f. rec/decoder CR76H; and the keyfob u.h.f. transmitter CR72P. (These are not cheap!) You could also try contacting **Veronica FM** (☎ ***01274 816200*** or ***http://www.veronicafm.co.uk***) or **Suma Designs** (☎ ***01827 714476***), who might be able to help here.

The BD681 Darlington transistor may be hard to find, but the suggested alternative TIP141 and TIP142 should be readily available. Note the differing pinouts for the TIP devices.

Ready programmed PICs are available from the author for the sum of £10 each (for either the Digital module or Stopwatch) or £50 for six in any combination, with free postage to anywhere in the world. *Payments should be made out to Mr. N. Stojadinovic.* His E-mail address is: ***vladimir@u030.aone.net.au*** or write to: **Mr. N. Stojadinovic, PO Box 320, Woden ACT, 2606, Australia**.

A programmed PIC16C55 is also available from **Magenta Electronics** (☎ ***01283 565435*** or ***http://magenta2000.co.uk***) for the inclusive price of £5.90 (overseas readers add £1 for postage). For those who wish to program their own PICs, the software is available from the Editorial Offices on a 3·5in., PC-compatible disk, see *EPE PCB Service* page. If you are an Internet user, it can be downloaded *Free* from our FTP site: **ftp://ftp.epemag.wimborne.co.uk/pubs/PICS/stopwatch**.

Regarding the door minder "guards", we are informed that most "through-beam detectors" will work with this project. The following sources and items have been suggested: ***Oatley Electronics, Australia*** (☎ ***029584 3563*** or ***www.oatleyelectronics.com***); **Kemo Electronics** (***www.kemo-electronic.com***) light barrier, code BD45: **Maplin** (***www.maplin.co.uk***) through beam detector, code SH09K; **Farnell** (☎ ***0113 263 6311*** or ***www.farnell.com***) miniature photoswitch, code 532-472. Check prices **before** ordering!

Finally, the printed circuit board is available from the *EPE PCB Service*, code 246.

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To help take the pressure off newcomers to the mysteries of electronics, some of our advertisers have put together component and hardware packs specially for the new *Teach-In 2000* series. More will be added as the series progresses.

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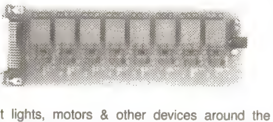

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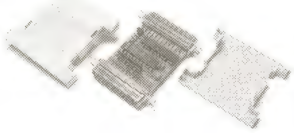
● **PIC 16C71 FOUR SERVO MOTOR DRIVER** Simultaneously control up to 4 servo motors. Software & all components (except servos/control pots) supplied. 5VDC. PCB 50x70mm. **3102-KT £13.95**

● **PC SERIAL PORT ISOLATED I/O BOARD** Provides eight 240VAC/10A relay outputs & 4 optically isolated inputs. Designed for use in various control & sensing applications e.g. load switching, external switch input sensing, contact closure & external voltage sensing. Controlled via serial port & a terminal emulator program (built into Windows). Can be used with ANY computer/operating system. Plastic case with printed front/rear panels & all components (except cable) provided. **3108-KT £44.95**

● **UNIPOLAR STEPPER MOTOR DRIVER** for any 5/6/8 lead motor. Fast/slow & single step rates. Direction control & on/off switch. Wave, 2-phase & half-wave step modes. 4 LED indicators. PCB 50x65mm. **3109-KT £12.95**

● **PC CONTROLLED STEPPER MOTOR DRIVER** Control two unipolar stepper motors (3A max. each) via PC printer port. Wave, 2-phase & half-wave step modes. Software accepts 4 digital inputs from external switches & will single step motors. PCB fits in D-shell case provided. **3113-KT £15.95**

● **12-BIT PC DATA ACQUISITION/CONTROL UNIT** Similar to kit 3093 above but uses a 12 bit Analogue-to-Digital Converter (ADC) with internal analogue multiplexor. Reads 8 single ended channels or 4 differential inputs or a mixture of both. Analogue inputs read 0-4V. Four TTL/CMOS compatible digital input/outputs. ADC conversion time <10uS. Software (C, QB & Win), extended D shell case & all components (except sensors & cable) provided. **3118-KT £44.95**



● **TRANSMITTER RECEIVER PAIR** 2-button keyfob style 300-375MHz Tx with 30m range. Receiver encoder module with matched decoder IC. **30A15 £13.95**

● **LIQUID LEVEL SENSOR/RAIN ALARM** Will indicate fluid levels or simply the presence of fluid. Relay output to control a pump to add/remove water when it reaches a certain level. **1080-KT £6.95**

● **UNIVERSAL TIMER** Seven crystal controlled timing operations in steps of 0.1s from 0.1-6553.6s or 1 second steps from 0.1-65536s. Allows 4 signal input types from push button to electrically isolated voltage switching sources. Onboard relay will switch 240V/5A. Box, software & all components provided. PCB 56 x 97mm. **3054-KT £24.95**

● **STEREO VU METER** shows peak music power using 2 rows of 10 LED's (mixed green & red) moving bar display. 0-30db. **3089-KT £10.95**

● **AM RADIO KIT 1** Tuned Radio Frequency front-end, single chip AM radio IC & 2 stages of audio amplification. All components inc. speaker provided. PCB 32x102mm. **3063-KT £9.95**

● **NEGATIVE\POSITIVE ION GENERATOR** Standard Cockcroft-Walton multiplier circuit. Mains voltage experience required. **3057-KT £8.95**

● **DRILL SPEED CONTROLLER** Adjust the speed of your electric drill according to the job at hand. Suitable for 240V AC mains powered drills up to 700W power. PCB: 48mm x 65mm. Box provided. **6074-KT *£15.90***

● **3 INPUT MONO MIXER** Independent level control for each input and separate bass/treble controls. Input sensitivity: 240mV. 18V DC. PCB: 60mm x 185mm **1052-KT *£16.95***

● **CAR ALARM SYSTEM** Protect your car from theft. Features vibration sensor, courtesy/boot light voltage drop sensor and bonnet/boot earth switch sensor. Entry/exit delays, auto-reset and adjustable alarm duration. 6-12V DC. PCB: 47mm x 55mm **1019-KT *£9.95*** Box ***£6.50***

● **ELECTRONIC SIREN 5 Watt.** Impressive 5W power output. Suitable for alarm systems, car, motorbikes, etc. Output frequency 1·2kHz. 6-12V DC. PCB: 37mm x 71mm. Siren not provided **1003-KT *£5.95***

● **DOG SILENCER/PEST SCARER** Are you going barking mad? Kit emits a blast of high intensity sound just out of the range of human hearing, but dogs will hear it easily. Works on most dogs except deaf or stupid ones! Effective range 30 metres. Supplied with PCB, all components and a high frequency tweeter. 10-16V DC/500mA **3026-KT *£17.95***

● **LED DICE** Classic intro to electronics & circuit analysis. 7 LED's simulate dice roll, slow down & land on a number at random. 555 IC circuit. **3003-KT £7.95**

● **STAIRWAY TO HEAVEN** Tests hand-eye co-ordination. Press switch when green segment of LED lights to climb the stairway - miss & start again! Good intro to several basic circuits. 3005-KT £7.95

● **ROULETTE LED** 'Ball' spins round the wheel, slows down & drops into a slot. 10 LED's. Good intro to CMOS decade counters & Op-Amps. **3006-KT £9.95**

● **DUAL LED DICE** PIC 16C54 circuit performs similar function to 3003-KT above but two dice. Good intro to micro-controllers. **3071-KT £11.95**

● **9V XENON TUBE FLASHER** Transformer circuit steps up 9V battery to flash a 25mm Xenon tube. Adjustable flash rate (0·25-2 Sec's). **3022-KT £10.95**

● **LED FLASHER 1** 5 ultra bright red LED's flash in 7 selectable patterns. **3052M-KT £4.50**

● **LED FLASHER 2** Similar to above but flash in sequence or randomly. Ideal for model railways. **3052M-KT £4.50**

● **16C84 PIC PROGRAMMER** Reads, programs & verifies. Uses any PC parallel port. All hardware, software & documentation needed to learn & test this uC provided. **3081-KT £20.95**

● **SERIAL PIC PROGRAMMER** for all 8/18/28/40 pin DIP serial programmed PICs. 3rd party software supplied expires after 21 days (costs US$25 to register): **3096-KT £12.95**

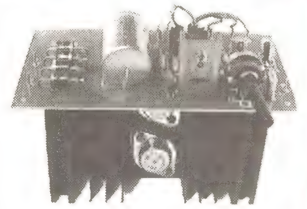
● **'PICALL' SERIAL & PARALLEL PIC PROGRAMMER** for all 8/18/28/40 pin DIP parallel AND serial PICs. Includes fully functional & registered software (DOS, W3.1, W95/8). **3117-KT £54.95**

● **ATMEL 89Cx051 PROGRAMMER** Simple-to-use yet powerful programmer for the Atmel 89C1051, 89C2051 & 89C4051 uC's. Programmer does NOT require special software other than a terminal emulator program (built into Windows). Can be used with ANY computer/operating system. **3121-KT £24.95**

● **3V/1·5V TO 9V BATTERY CONVERTER** Replace expensive 9V batteries with economic 1.5V batteries. IC based circuit steps up 1 or 2 'AA' batteries to give 9V/18mA. **3035-KT £4.95**

● **STABILISED POWER SUPPLY 3-30V/2.5A** Ideal for hobbyist & professional laboratory. Very reliable & versatile design at an extremely reasonable price. Short circuit protection. Variable DC voltages (3-30V). Rated output 2.5 Amps. Large heatsink supplied. You just supply a 24VAC/3A transformer. PCB 55x112mm. Mains operation. **1007-KT £17.50. Custom Designed Box 2007 £34.95**

● **STABILISED POWER SUPPLY 2-30V/5A** As kit 1007 above but rated at 5Amp. Requires a 24VAC/5A transformer. **1096-KT £29.95. Custom Designed Box 2096 £34.95**



● **RFI POWER SUPPLY** Designed to power RF transmitters/receivers. Blocks high frequencies & eliminates problems like noise, overheating, standing waves, etc. Output: 12-14VDC/3A. Thermal/short circuit protection & electronic stabilisation. You just supply a 18VAC/3A transformer. PCB 72x82mm. **1171-KT £24.95**

● **MOTORBIKE ALARM** Uses a reliable vibration sensor (adjustable sensitivity) to detect movement of the bike to trigger the alarm & switch the output relay to which a siren, bikes horn, indicators or other warning device can be attached. Auto-reset. 6-12VDC. PCB 57x64mm. **1011-KT £10.95 Box £5.95**

● **LIGHT ALARM** Protect your valuables. Alarm sounds if circuit detects smallest amount of light. Place in cash box etc. **3008-KT £4.50**

● **PIEZO SCREAMER** 110dB of ear piercing noise. Fits in box with 2 x 35mm piezo elements built into their own resonant cavity. Use as an alarm siren or just for fun! 6-9VDC. **3015-KT £8.95**

● **COMBINATION LOCK** Versatile electronic lock comprising main circuit & separate keypad for remote opening of lock. Relay supplied. **3029-KT £8.95**

● **ULTRASONIC MOVEMENT DETECTOR** Crystal locked detector frequency for stability & reliability. PCB 75x40mm houses all components. 4-7m range. Adjustable sensitivity. Output will drive external relay/circuits. 9VDC. **3049-KT £11.95**

PIR DETECTOR MODULE 3-lead assembled unit just 25x35mm as used in commercial burglar alarm systems. **3076-KT £7.95**

● **INFRARED SECURITY BEAM** When the invisible IR beam is broken a relay is tripped that can be used to sound a bell or alarm. 25 metre range. Mains rated relays provided. 12VDC operation. **3130-KT £10.95**

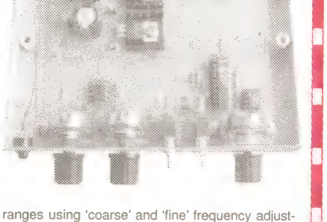
● **FUNCTION GENERATOR** Quad Op-Amp oscillator & wave shaper circuit generates audio range square waves (6Hz-6KHz), triangle & pseudo sine outputs. 9VDC. **3023-KT £3.95**

● **LOGIC PROBE** tests CMOS & TTL circuits & detects fast pulses. Visual & audio indication of logic state. Full instructions supplied. **3024-KT £6.95**

● **SQUARE WAVE OSCILLATOR** Generates square waves at 6 preset frequencies in factors of 10 from 1Hz-100KHz. Visual output indicator. 5-18VDC. Box provided. **3111-KT £7.95**

● **PC DRIVEN POCKET SAMPLER/DATA LOGGER** Analogue voltage sampler records voltages up to 2V or 20V over periods from milli-seconds to months. Can also be used as a simple digital scope to examine audio & other signals up to about 5KHz. Software & D-shell case provided. **3112-KT £18.95**

● **20 MHz FUNCTION GENERATOR** Square, triangular and sine waveform up to 20MHz over 3 ranges using 'coarse' and 'fine' frequency adjustment controls. Adjustable output from 0-2V p-p. A TTL output is also provided for connection to a frequency meter. Uses MAX038 IC. Plastic case with printed front/rear panels & all components provided. 7-12VAC. **3101-KT £49.95**



ELECTRONICS CD-ROMS

ANALOGUE ELECTRONICS

by Mike Tooley

Analogue Electronics is a complete learning resource for this most difficult branch of electronics. The CD-ROM includes a host of virtual laboratories, animations, diagrams, photographs and text as well as a SPICE electronic circuit simulator with over 50 pre-designed circuits.

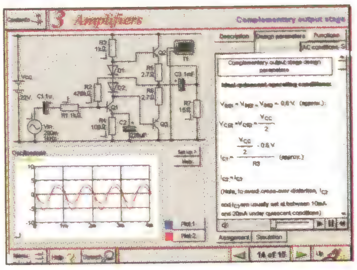
FUNCTIONS

The component values on all circuits can be edited and the user can use the simulation engine to see how the value of each component affects circuit performance. You can, for instance, alter frequency and phase angle and plot outputs on a virtual oscilloscope or show load line graphs etc.

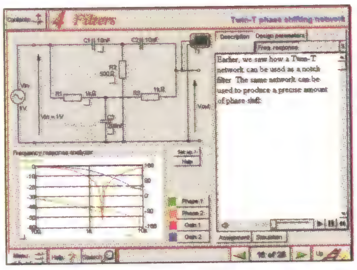
COVERAGE

Sections on the CD-ROM include: **Fundamentals** – Analogue Signals (5 sections), Transistors (4 sections), Waveshaping Circuits (6 sections); **Op.Amps** – 17 sections covering everything from Symbols and Signal Connections to Differentiators; **Amplifiers** – Single Stage Amplifiers (8 sections), Multi-stage Amplifiers (3 sections); **Filters** – Passive Filters (10 sections), Phase Shifting Networks (4 sections), Active Filters (6 sections); **Oscillators** – 6 sections from Positive Feedback to Crystal Oscillators; **Systems** – 12 sections from Audio Pre-Amplifiers to 8-Bit ADC plus a gallery showing representative p.c.b. photos.

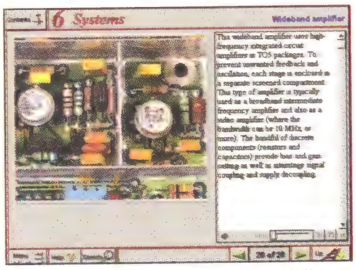
- **Includes SPICE circuit simulator with over 50 circuits**
- **Unique virtual laboratories**
- **Editable assignments**
- **Design parameters for circuits included**
- **Complete hi-fi amplifier case study**



Complimentary output stage.



Twin-T phase shifting network

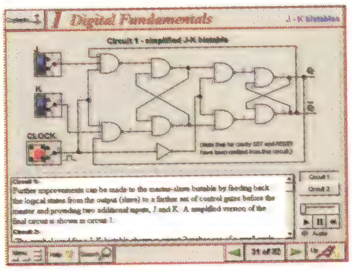


Gallery – Wideband Amplifier

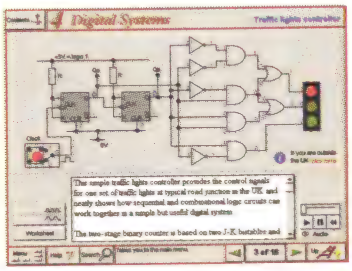
DIGITAL ELECTRONICS

by Mike Tooley

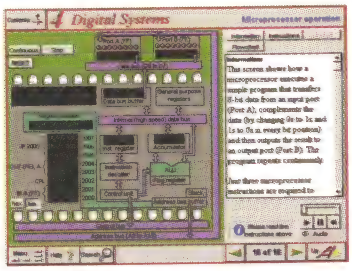
Digital Electronics builds on the knowledge of logic gates covered in *Electronic Circuits & Components* (below), and takes users through the subject of digital electronics up to the operation and architecture of microprocessors. The virtual laboratories allow users to operate many circuits on screen.



Virtual laboratory – Flip-Flops



Virtual laboratory – Traffic Lights



Microprocessor

FUNDAMENTALS

Fundamentals introduces the basics of digital electronics including binary and hexadecimal numbering systems, ASCII, basic logic gates and their operation, monostable action and circuits, and bistables – including JK and D-type flip-flops.

COMBINATIONAL LOGIC

Multiple gate circuits, equivalent logic functions and specialised logic functions such as majority vote, parity checker, scrambler, half and full adders. Includes fully interactive virtual laboratories for all circuits.

SEQUENTIAL LOGIC

Introduces sequential logic including clocks and clock circuitry, counters, binary coded decimal and shift registers.

DIGITAL SYSTEMS

A/D and D/A converters and their parameters, traffic light controllers, memories and microprocessors – architecture, bus systems and their arithmetic logic units.

GALLERY

A catalogue of commonly used IC schematics taken from the 74xx and 40xx series. Also includes photographs of common digital integrated circuits and circuit technology.

Prices for each of the two CD-ROMs above are:

Hobbyist/Student ....**£45 inc VAT**
Institutional (Schools/HE/FE/Industry)..............**£99 *plus* VAT**
Institutional 10 user (Network Licence)..........**£199 *plus* VAT**

(UK and EU customers add VAT at 17.5% to "plus VAT" prices)

TWO APPLICATIONS ON ONE CD-ROM

ELECTRONIC CIRCUITS & COMPONENTS + THE PARTS GALLERY *by Mike Tooley*

Electronic Circuits & Components provides an introduction to the principles and application of the most common types of electronic components and shows how they are used to form complete circuits. The virtual laboratories, worked examples and pre-designed circuits allow students to learn, experiment and check their understanding as they proceed through the sections on the CD-ROM. Sections on the disk include: ***Fundamentals:*** units & multiples, electricity, electric circuits, alternating circuits. ***Passive Components:*** resistors, capacitors, inductors, transformers. ***Semiconductors:*** diodes, transistors, op.amps, logic gates. ***Passive Circuits***. ***Active Circuits***

The Parts Gallery – many students have a good understanding of electronic theory but still have difficulty in recognising the vast number of different types of electronic components and symbols.

The Parts Gallery helps overcome this problem; it will help students to recognise common electronic components and their corresponding symbols in circuit diagrams. Selections on the disk include: ***Components ,Components Quiz, Symbols, Symbols Quiz, Circuit Technology***

Hobbyist/Student ....**£34 inc VAT**
Institutional (Schools/HE/FE/Industry) ....**£89 *plus* VAT**
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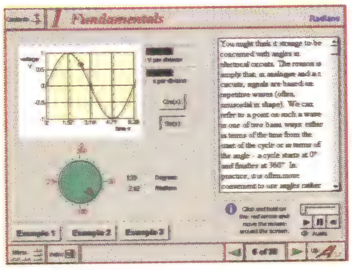
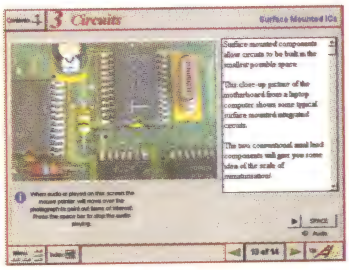
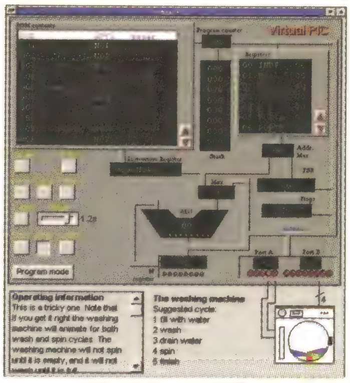


Virtual laboratory – sinusoids



Circuit technology screen

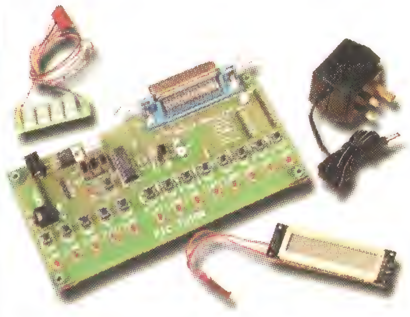
Interested in programming PIC microcontrollers? Learn with PICtutor by John Becker



Operating information
This is a tricky one. Note that if you get it right the washing machine will animate for both wash and spin cycles. The washing machine will not spin until it is empty, and it will not wash until it is full.

The washing machine
Suggested cycle:
1 fill with water
2 wash
3 drain water
4 spin
5 finish

The Virtual PIC



Deluxe PICtutor Hardware

This highly acclaimed CD-ROM, together with the PICtutor experimental and development board, will teach you how to use PIC microcontrollers with special emphasis on the PIC16x84 devices. The board will also act as a development test bed and programmer for future projects as your programming skills develop. This interactive presentation uses the specially developed **Virtual PIC Simulator** to show exactly what is happening as you run, or step through, a program. In this way the CD provides the easiest and best ever introduction to the subject.

Nearly 40 Tutorials cover virtually every aspect of PIC programming in an easy to follow logical sequence.

HARDWARE

Whilst the CD-ROM can be used on its own, the physical demonstration provided by the **PICtutor Development Kit**, plus the ability to program and test your own PIC16x84s, really reinforces the lessons learned. The hardware will also be an invaluable development and programming tool for future work once you have mastered PIC software writing.

Two levels of PICtutor hardware are available – Standard and Deluxe. The **Standard** unit comes with a battery holder, a reduced number of switches and no displays. This version will allow users to complete 25 of the 39 Tutorials.

The **Deluxe** Development Kit is supplied with a plug-top power supply (the **Export** Version has a battery holder), all switches for both PIC ports plus l.c.d. and 4-digit 7-segment l.e.d. displays. It allows users to program and control all functions and both ports of the PIC and to follow the 39 Tutorials on the CD-ROM. All hardware is supplied **fully built and tested** and includes a PIC16F84 electrically erasable programmable microcontroller.

PICtutor CD-ROM

Hobbyist/Student	**£45 inc. VAT**
Institutional (Schools/HE/FE Industry)	**£99 *plus* VAT**
Institutional 10 user (Network Licence)	**£199 *plus* VAT**

HARDWARE

Standard PICtutor Development Kit	**£47 inc. VAT**
Deluxe PICtutor Development Kit	**£99 *plus* VAT**
Deluxe Export Version	**£96 *plus* VAT**

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MODULAR CIRCUIT DESIGN by Max Horsey and Philip Clayton

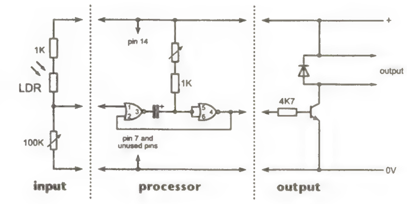
This CD-ROM contains a range of tried and tested analogue and digital circuit modules, together with the knowledge to use and interface them. Thus allowing anyone with a basic understanding of circuit symbols to design and build their own projects.

Essential information for anyone undertaking GCSE or "A" level electronics or technology and for hobbyists who want to get to grips with project design. Over seventy different Input, Processor and Output modules are illustrated and fully described, together with detailed information on construction, fault finding and components, including circuit symbols, pinouts, power supplies, decoupling etc.

Single User Version £19.95 inc. VAT
Multiple User Version £34 *plus* VAT

(UK and EU customers add VAT at 17.5% to "plus VAT" prices)

designing your circuit
simply select your modules from the wide choice available, read how they work and join them up to make your circuit



"I found that I could design a circuit without my teacher's help. And it worked! Everything was to hand – which chips to use – and which pins did what." Andrew Preston (GCSE student)

A Web Browser is required for Modular Circuit Design – one is provided on the *EPE CD-ROM No. 1* (see below) but most modern computers are supplied with one.

Minimum system requirements for these CD-ROMs: PC with 486/33MHz, VGA+256 colours, CD-ROM drive, 8MB RAM, 8MB hard disk space. Windows 3.1/95/98/NT, mouse, sound card (not required for *PICtutor* or *Modular Circuit Design*).

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Note: The software on each version is the same, only the licence for use varies.

☐ **PICtutor Development Kit – Standard**
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Demos (not Modular Circuit Design) available on the ***EPE CD-ROM No. 1*** (Free with the November '98 issue of *Everyday Practical Electronics* magazine) – send £2 for this CD-ROM if you require the demos. **Minimum order** for credit card payment is £5.

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AVR – 1200,2313,4144,8515 in ZIF. **Price: £40/kit £45 built & tested.**

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PIC BASIC Products - See our web site for details
16C74 version (8Kbyte EEPROM) - 20 MHz
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READOUT

John Becker addresses some of the general points readers have raised. Have you anything interesting to say? Drop us a line!

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A $3^{1}/_{2}$ digit pocket-sized l.c.d. multimeter which measures a.c. and d.c. voltage, d.c. current and resistance. It can also test diodes and bipolar transistors.

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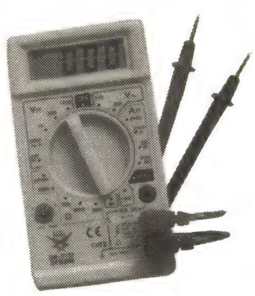


★ LETTER OF THE MONTH ★

DRAFTING STRIPBOARDS

Dear EPE,

This suggestion describes a method of using a p.c.b. design package to generate a stripboard layout with the security of schematic capture (using a netlist):

1. Use your P.C.B. Library Editor to make up the various lengths of resistors (from vertical to stretched) as used on stripboard layouts. I gave them names such as VERORES2 (vertical) to VERORES7 (stretched). Make an X using a non-copper layer to mark track cuts. Make sure the origin of the X object is at the centre of the X.

2. Use your P.C.B. Library Editor to make up any component outlines not already in your library.

3. Open both Schematic and P.C.B. packages and make new files with appropriate filenames. In the P.C.B. package select a 0.1-inch visible and electrical grid. Mark the outline of your maximum board size on a non-copper layer. Set the Via size to small but visible (e.g. a few mil) as these join the top layer (vertical wire links) to the bottom layer (horizontal stripboard tracks).

4. Draw out the circuit in the schematic package filling in appropriate P.C.B. outlines (some may be changed later). Generate a netlist.

5. Load the netlist and outlines into the P.C.B. package and place them roughly. If one variant of an outline does not fit the layout then return to step 4 and change the component's outline to a more suitable one (e.g. make a resistor vertical) then repeat this step.

6. Join up the components using bottom layer copper as stripboard horizontal tracks, top layer copper as vertical "wire links", joined with Vias (to allow the P.C.B. package to check the layout matches the schematic). Also, mark track breaks with the library outline you created for this purpose.

7. When the layout is finished make the P.C.B. package check that the connections in the stripboard layout match those of the schematic.

8. When the stripboard layout is finished mark the outline of the used board space with a non-copper layer and then mark it with small pads (one per 0.1-inch step of the outline). This can be done quickly by using the Copy command. These pads will be useful for showing the 0.1-inch grid on the layout printout.

9. Now printout the stripboard layout. Using the outline pads as reference, number the rows and columns. Check that all necessary track breaks have been included. Drawing a vertical and/or horizontal 0.1-inch grid in pencil may help make the layout more readable.

10. Finished. Build the layout.

Alan Bradley,
Belfast Northern Ireland

It certainly sounds like a very viable method for stripboard designing without using a commercial package. Thanks Alan, we are very pleased to give your suggestion Letter of the Month *status – hope you get good use of your new meter!*

BYTING HISTORY

Dear EPE,

Having taken early retirement I resolved to renew my old hobby and was pleased to see your *PIC Toolkit Mk2* (May-Jun '99) which I built. Having only the *EPE* copies since March this year, and therefore not having details of the *PIC Tutorial* (March-May '98), I used the spare space on the Mk2 board to fit eight l.e.d.s with 1k dropping resistors. These were connected to the Port B outputs and I fitted a 2-way d.i.l. switch in the common feed from the l.e.d.s to the negative supply so that they can be switched off in banks of four if the port is configured for inputs.

The unit works fine but I did find that the output from my PC on the Centronics socket pins was around 3·8V rather than 5V. Also, it was necessary to switch off the l.e.d.s connected to PIC pins RB6 and RB7 to get programming to work.

I also find that I cannot use the first few program memory addresses (0 to 3) for holding program data.

If you can give me any guidance as to the cause of these problems I would be grateful.

I am really enjoying your magazine and am very impressed with the way you share the programs you create so freely. I do wonder a bit at who all your contributors are? I notice you admit to struggling with the values of tiny components (and I sympathise) and I too remember red spot transistors at 10 bob a time, so I am curious about your backgrounds. Have you given a potted history of each of your contributors recently and maybe a small photo (recent of course!) at the head of each article would give a bit more detail.

Bruce Beattie, via the Net

On the Port problem, you should not connect external components directly to RB6 and RB7 because of the 1k buffer resistors (R9 and R10) that are in circuit during programming. Doing so may, as you appear to have found, attenuate the programming logic levels received by the Port. External connections for RB6 and RB7 should only be made at the allocated positions on the p.c.b. which are via the Y0 and Z0 paths of isolating gate IC6.

The PIC16x84 does not allow the use of the first five bytes (0 to 4) of program memory space for actual programming purposes. All five bytes are reserved for Interrupt and Jump Vector data, plus program identity coding. Toolkit Mk2 (and previous EPE '16x84 programmers) automatically places vector data at these locations prior to sending the body of the program itself. All program data should, therefore, commence at address byte 5.

*History-wise you can find a byte or two about us via our website (**http://www.epemag.wimborne.co.uk.**) – you'll find the click-link access address on the "title page" of this site. Pictorially, though, we are not prepared to expose ourselves! Suffice to say that we have been compared to Greek gods (but how favourably remains our secret)!*

TV AND VIDEO COURSES

Dear EPE,

Firstly let me congratulate you, your staff and all the contributors to your magazine on producing one of the best and most informative magazines relating to electronics and technology of that kind for both the novice and the professional.

I am a lecturer in audio, video and electronic engineering at Cardonald College in Glasgow which has offered courses in TV, video and electronic engineering for many years to the service industry in Scotland.

In the September issue of your magazine an article appeared in the *News* section from the College of North West London, stating that they were the only FE college in the UK to provide digital TV training courses in the servicing of these types of system. I'm afraid that is not quite accurate as we offer an HNC course in HNC Television and Audio Visual Media Engineering, which includes both satellite and digital TV decoder servicing.

To cover many of the changes that have taken place in technology over the last few years we have written three new HNC Units titled: *Satellite and Digital Television Principles, Audio Home Entertainment Systems: Principles and Testing,* and lastly *Video Displays and Video Recorder Servicing.* These units were created in consultation with service organisations such as Granada and Scottish Power whose contributions, as well as those from other companies and firms, enabled us to make the content as up-to-date as possible.

The college offers the HNC in HNC Television and Audio Visual Media Engineering as a one year full-time course or day release involving one day's attendance at college per week over two years. For further information on the above course contact Karen Byrne, Cardonald College, 690 Mosspark Drive, Glasgow G52 3AY. Tel: 0141 272 3223. Fax: 0141 272 3444. Or phone our information centre on 0141 272 3332.

Tom Connelly,
Lecturer, Division of Technology,
Cardonald College, Glasgow

The vast majority of our News *stories (except those with Barry Fox's byline) are based on material supplied to us by the organisation concerned. It was the College of North West London who advised us of the uniqueness of their courses. We are pleased to learn that such courses are available more widely.*

CAP THAT!

Dear EPE,

Keep up the pointless projects please – sundials should be electronic! How about an electric milk-bottle decapper?

R.A. Evans, Hastings, Sussex

And that was that! – just a simple postcard with a happy smiling face outline on the front. But it's arrival was much appreciated, we like to be told from time to time that we are doing things right (in this instance by publishing my Musical Sundial *of June '99). Thanks, RAE (we don't know your first name).*

Does anyone else have a pointless idea that might actually have an electronic application – wind chimes have been suggested?

LEAPING CALENDARS (1)

Dear EPE,

Re the letter from R.L.A. Latham, in *Readout* Sept '99, who correctly proved that the calendar days of the year 2000 exactly match up to those of 1972. Assuming a leap year comes round once every four years, the time for a complete cycle (the weekdays advance by one on each non-leap year) is the lowest common multiple of four and seven – 28. So altering the date to 1972, 1944, etc. produces an identical calendar to 2000.

However, there is another rule, commonly overlooked, that every century year (1800, 1900, etc.) is not a leap year. There is yet another exception that every fourth century is a leap year, that is why 2K is a leap year and 2400 will be too. This all comes from the fact that, as the *Penguin Dictionary of Science 1993* puts it: "The civil year has an average value of 365·2425 mean solar days" – unlike 365·25 as many believe.

So the overall period for the leap year pattern is 400 years. The lowest common multiple of 400 and 7 gives the total period of the date cycle, which turns out to be 2800 years! To be sure of the correct date and weekday, you have to advance or rewind the date by 2800 years, which is only possible with Y2K compliant computers – defeating the object. (Don't try setting the Sinclair to 800BC!) For now, ±28 years will work, but only until 2099!

Thanks for such a great magazine, I have especially enjoyed the *PIC Tutorial* series of Mar-May '98, and have now developed a few projects of my own. It can be very challenging but also rewarding. I shall also be studying the *PIC16F87x Mini Tutorial* of Oct '99, and hope to make use of the serial communications that the PIC16F87x devices offer.

David Thompson,
Sutton Coldfield, West Midlands

Thanks David for a great response. It's ironic that despite all our abilities to rationalise so many matters into neat well-ordered mathematical structures, our calendar can never be revised into a perfectly uniform table of equal-length months and years.

Whilst in everyday life we take the calendar's idiosyncrasies in our stride, when writing programs (e.g. for PIC projects) that require time and date info to be used or displayed, an awful lot of valuable memory space is taken up by all the variables and sub-routines involved to achieve the required result. If only it all could be uniformly decimalised or "binary-ised"!

Think also about the problems that will ultimately be experienced by our descendents when the planets of this and other solar systems are colonised. Each will have its own very specific calendar and clock requirements. On our planet the various time zones have to be taken into account when communicating globally. There will be even greater time zone factors to be considered for interplanetary communication, including of course, transmission time-lags.

LEAPING CALENDARS (2)

Dear EPE,

Following up on *Readout* Sep '99, the Gregorian calendar (used in England since 1752) does a complete cycle in 400 years, and a sub-cycle in 28 years which is "disturbed" by the century leap year rule. There are 14 types of year, according to the day of the week on which they start and the day on which they end (same weekday in non-leap years and obviously one day later in leap years).

If you keep your calendars you can recycle them but the non-leap year ones come round every five or six years, whereas the leap-year ones have to be kept for 28 years. 1999 is "Fri-Fri" and I am re-re-recycling a 1982 calendar at present! 2000 is a "Sat-Sun" year, and as I don't have one of these from 1978, I guess I will buy one!

Chris Finn, Beverley, East Yorkshire

Thanks Chris. Shame about 1978 – what an unnecessary expense you're going to have!

DREAM MACHINE

Dear EPE

As far back as I can remember, I have been unable to sleep. (I go back to the old *Practical Wireless* and, dare I mention them, valves!)

This condition of insomnia is miserable and for more than 20 years I have used music tapes, self-hypnosis tapes and books. When biofeedback was developed, I built and used all electronic devices that I saw published in magazines such as yours. Biofeedback teaches the control of autonomic functions, such as the rate of heartbeat or breathing. They attempt to measure the brain waves produced when relaxed. With all this time and effort I managed to sometimes get one, two, or possibly three nights reasonable sleep. After that, something seemed to stop that particular thing working for me.

So I read Andy Flind's *Mood PICker* article (July '99) with extra interest. This approaches the problem from the other end, generating the requisite brain frequency that hopefully the brain can imitate, thus giving relaxation or whatever.

Having built the design, I have been using it for about two months. I don't yet sleep all through the night but what sleep I do get is, for me, of a high order. I have just begun to dream. I awoke suddenly from one dream that seemed so real that it took some minutes to establish that it had been a dream.

I have to thank you and Andy Flind. This is a tribute to your magazine for keeping at the cutting edge of technology. It shows the value in research and development for the hobbyist.

I hope that you will print this letter. This may not be the answer for all electronic insomniacs but perhaps encourage some. I am persuaded that there are many of us out here.

Michael D. Walker,
Northfield, Birmingham

We are delighted that Andy's project has helped you, as it has other readers. Andy is, I should praisingly comment, our expert on matters to do with electronic control and sensing of the brain's activities. We have sent a copy of your letter to him.

ONLINE P.C.B.S

Dear EPE,

I'm about to make Andy Flind's *Mind PICkler* (Dec '98, Jan '99) from the information I downloaded via *EPE Online*, and for that purpose I redrew the complete p.c.b. layout in WinCircuit. May I comment that it would be a great practice for you to put postscript files of p.c.b. layouts on your home page for everyone to access!

Incidentally, I am a Mac user who asked you about alternative means of accessing your *Online* issues. As a result of your helpful reply I plan to install a complete Windows emulator on my Mac just to be able to read your magazine!

Tomislav Ribicic, via the Net

We hope we have now solved both of your problems, our new system can be downloaded on Macs and other computers – see last month's News. *We have also managed to crack the p.c.b. problem and Postscript files are now downloadable for our p.c.b.s from the October '99 issue onwards.*

It's great to know we have inspired you!

HIGH LEVEL LOGGING

Dear EPE,

Thank you very much for your *Data Logger* (Aug-Sep '99) and the explanation of how to convert data into graphs, something which I have been trying to find the answer to for some months. I have now ordered a kit from one of your advertisers.

There is one thing that I now need to find out, how can I extract a suitable signal from my *PIC Altimeter* (Sep '98), so that I can plot barometric changes?

Pat Darragh, via the Net

Thanks Chris, and the answer's simple – connect one of the Logger's *input channels to the* Altimeter's *IC1d pin 7.*

CONGRATS ONLINE – FREELY!

Dear EPE,

Congratulations for two jobs well done.

First, for Raymond Haigh's *Practical Oscillator Designs* series of articles currently being published since July '99. In the course of building a Theremin, I did a lot of research into oscillators. These articles are by far the most thorough I have seen anywhere. I hope he is planning to cover electronic tuning of oscillators.

Second, for the *Online* version of the magazine. Even in a city as big as Dallas, Texas, this "foreign" magazine is hard to find. My regular source recently went out of business. I was able to find one more source but it is probably the only source in the entire city. The *Online* version solves that problem. The fact that it costs less than 1/5th the price of the hardcopy version makes it a clear winner.

I have downloaded my first issue and am very pleased with it. For better international use, the page size is the smaller American 8·5 × 11 inches instead of the larger European A4. The table of contents allows easy browsing of the entire issue, and the print quality is excellent; even the very fine print in schematic diagrams is readable.

I am a little surprised that the advertisements were not included. Folks in "well-developed" countries and cities probably would buy locally, but people in less fortunate locations might buy from your advertisers, especially since the *Shoptalk* feature only lists those companies. I was expecting your revenue from the advertisers who wanted the increased international coverage to be one of the reasons the price is so low. Apparently, eliminating the need for paper publication and mailing is the major cost reduction.

As a side note, in the *Shoptalk* feature, the **www** addresses of the companies are PDF links, but generate an error when clicked on. If there is no way to make Acrobat open the browser, there is no use taking the trouble to make the URLs links.

Glenn Manuel,
Richardson, Texas, USA, via the Net

Glenn sent his E-mail to our EPE Online *Editors, Max and Alvin, in the States, who reply:*

The hyperlinks in the PDF documents should launch Glenn's browser – they certainly launch other people's browsers. One point is that he has to have an Internet connection open for the browser to work. Another point is that his system has to be set up to have the default action on clicking a hyperlink (in any document) to launch his default browser.

The reason the *Online* mag can be so cheap is not that we cut out the paper, print costs, and distribution . . . it's that EPE HQ provides the material for free and we do all the work without getting paid :-)

Max and Alvin

But you do get the pleasure of it all – why sully matters with finance?! We expect to add banner adverts with links to advertisers' web sites soon.

DR DOS

Dear EPE,

R.A. Hooper's problem (*Readout* Oct '99) might be solved by looking at the problem another way. Assuming his "editor" program is in the **C:\DRDOS** directory, he could try adding a one-line batch file called **EDIT.BAT**, something like as follows:

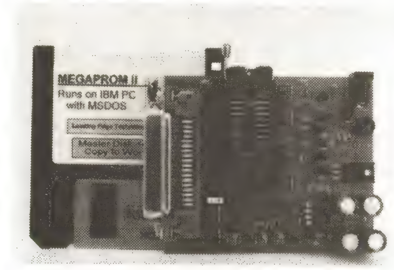
```
C:\DRDOS\EDITOR
```

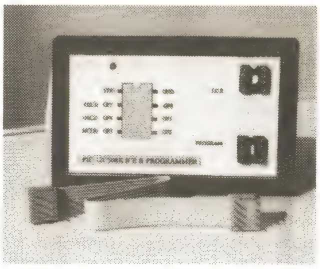
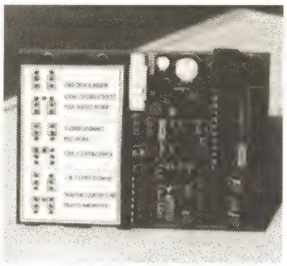
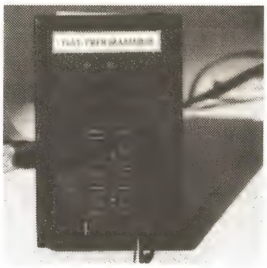
This would cause *Toolkit* to run the batch file running the program. At the termination of the program the batch file would similarly terminate so the action would appear almost seamless.

If he opens his editor program normally, types the above line substituting "DRDOS" for the right directory and saves it as **EDIT.BAT** in the **C:\PIC** directory, all might work.

David Geary, via the Net

Thanks David, your suggestion has been sent to R.A. Hooper, who will hopefully let us know the effect it has.



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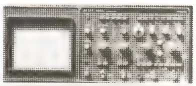
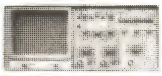
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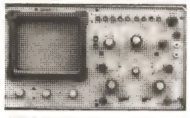
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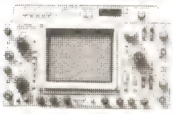
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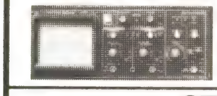
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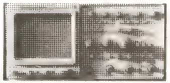
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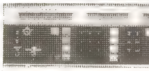
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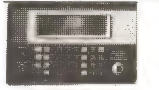
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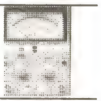

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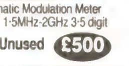
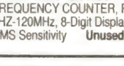
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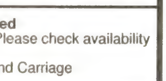
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PRACTICALLY SPEAKING

Robert Penfold looks at the Techniques of Actually Doing It!

AT LEAST one semiconductor device is an essential part of any modern electronic project. The word semiconductor covers everything from a humble diode right up to the latest microprocessor containing the equivalent of millions of components. Simple semiconductors such as transistors and diodes are still used to some extent in modern electronic circuits, but most designs now seem to be based on integrated circuits (i.c.s).

Finding the right semiconductors in component catalogues can often be problematic for beginners. Indeed, integrated circuits are probably the most difficult to deal with because they tend to be divided into various categories.

You have to look for each device under the right category in order to stand any chance of finding it. Alternatively, there may be a complete list of devices that you can search through, but unless you know what you are doing it can be difficult and very time consuming to locate a device from a list having many thousands of entries.

Numbers Up

Finding the right component is much easier if you understand the fundamentals of integrated circuit type numbers. There may be some exceptions, but practically all integrated circuits have type numbers which break down into three sections.

The first part of the number is usually two or three letters that indicate the manufacturer. Each manufacturer may use more than one set of letters, with linear devices perhaps having a different prefix to logic types.

Another complication is that many integrated circuits are second-sourced. Industrial customers do not like being tied to a single source of supply, so many integrated circuits are manufactured under license by a second manufacturer. These second-source components may retain the original type number, or the prefix may be changed to that of the second-source manufacturer.

The practical consequence of this is that you do not have to worry too much if the first two or three letters in the type number of the device you obtain are not what you were expecting. If you require an MC1458CP but are supplied with a CA1458E there is no need to panic. They are the same chip manufactured respectively by Motorola and RCA.

Some popular devices, including this dual operational amplifier, are actually manufactured by several companies, and can be obtained with various prefixes in the type number. This is not an entirely satisfactory state of affairs, as there is plenty of scope for errors to occur.

In order to minimise the risk of the wrong parts being ordered manufacturers try to avoid duplication of the middle part of the number, which is the actual type number. This is usually from three to five characters long, and consists entirely of numerals. It is not inconceivable that you could find a semiconductor that is completely different to the device you require but has the same type number.

In practice the chances of this happening are extremely remote, but it does no harm to look at the descriptions of semiconductors to see if they match up with the required device. If a design requires an operational amplifier but the device you find in a component catalogue is a timer chip, it is clearly the wrong device and you must continue searching through the catalogue.

Little Packages

The final part of the type number indicates the package type, and is usually one or two letters. The integrated circuits used in designs for the home constructor are normally contained in a d.i.l. (dual-in-line) plastic encapsulation. Dual-in-line simply means that the component has two rows of pins.

Unfortunately, manufacturers do not all use the *same* suffix letters for a given package type. In our earlier example of the same device under two different type numbers, the suffix letters were "CP" and "E".

In the first type number the "C" and "P" respectively indicate a dual-in-line package and that it is made from plastic. In the second example the single letter "E" means exactly the same thing. With other manufacturers the suffix for this type of encapsulation is "CN", "C", "N", "CS", "P", and "G". No doubt there are many other alternatives.

On the Surface

At one time some devices were offered to amateur users in more than one case style, but this practice now seems to have died out. These days most components catalogues only list the standard plastic cased version of each integrated circuit, so there is no need to worry too much about the suffix.

However, some catalogues do now include a few surface-mount versions (SMDs), so you need to tread a little warily when ordering devices that are listed in two versions. The component catalogue should make it perfectly clear which device is which.

In most catalogues there are so many integrated circuits on offer that they are put into several categories to make life easier when searching for a device. There will normally be two categories of logic device, which are the *4000 series CMOS* integrated circuits and the *74 series TTL* chips.

At one time there were the original "A" suffix CMOS devices and the newer "B" series components. The "A" series have been obsolete for many years now, and all the devices listed in the catalogues are "B" series chips. If you dig up an old design, as many readers seem to do, there should be no problem in using "B" series CMOS components where "A" series chips are specified.

Things are less straightforward with the TTL integrated circuits. These exist in several improved ranges, and the original range is now obsolete.

The main type number of the original devices has "74" as the first two digits, followed by a two or three digit serial number. This basic scheme of things is retained in the current devices, but some letters are added between the "74" and the serial number to denote which family the device comes from.

This is "LS" for low-power Schottky, "HC" for high-speed CMOS and "HCT" for the high-speed CMOS devices that operate at normal TTL voltage levels. The original 7421 is therefore available as the 74LS21, the 74HC21, and the 74HCT21.

In fact there are many other improved TTL ranges, but most are now obsolete or not generally available. There is a general lack of compatibility between the different families of TTL integrated circuits, and it is very important to ensure that you always obtain the correct version.

In most component catalogues the non-logic devices tend to be lumped together under the general heading of *"linear"* integrated circuits. This category covers a wide range of integrated circuits including audio and other low frequency devices, radio and other communications chips, timers, oscillators, etc. If you require something other than a standard logic device it will probably be in the linear devices, even if it is not strictly speaking a linear component.

Voltage Regulators

You may find voltage regulators in the linear section, but they often have a section of their own. In component lists, and often in catalogues, many of the more common voltage regulators are listed under their basic type numbers with no prefixes and suffixes.

This is simply because these devices are manufactured by numerous companies and they consequently have a bewildering range of full type numbers. In some cases the type numbers may be abandoned altogether, with the voltage and current ratings being specified instead.

Current Affairs

Voltage regulators are easier to deal with if you understand the way in which the basic type numbering operates for the common fixed voltage types. Regulators for use with *positive* supplies have a type number that starts "78", and those for operation with *negative* supplies have type numbers that begin with "79".

For a device that will operate at up to one amp (1A) the next part of the type number is two digits that indicate the output voltage. For example, the two digits are "05" for a 5-volt regulator and "15" for a 15-volt type. There are about half a dozen or so standard output voltages from five to 30 volts.

Regulators having other operating currents are available, and a letter inserted in the middle of the number indicates the current rating. This is "L" for 0·1A, "M" for 0·5A, and "S" for 2A. A component having 78L12 as its type number would therefore be a 12V, 0·1A positive voltage regulator, and one having 7905 as the type number would be a 5V 1A negative regulator.

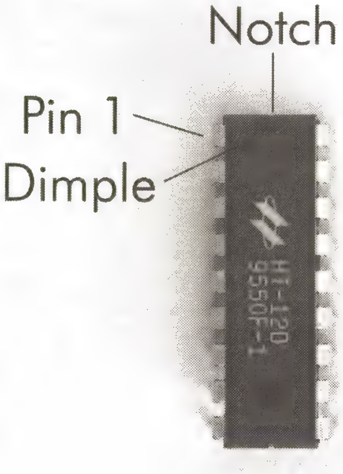

Fig.1. The two normal methods of identifying pin one of an i.c.

Marked Concern

Beginners are often concerned at the extra markings found on most integrated circuits, and on some other components such as transistors and capacitors. One of these will usually be the manufacturer's logo, and the country of manufacture will sometimes be shown.

Any other markings are unlikely to be of any significance at all. Any additional numbers are just things like batch numbers, or the date of manufacture in some oddly coded form, such as the number of days since the factory was opened.

You soon get used to picking out the type number and ignoring all the extraneous characters.

Getting Physical

Getting integrated circuits fitted onto the circuit board correctly should be very straightforward. Most integrated circuits are contained in d.i.l. packages having from 8 pins to 40 pins.

It is possible to fit a device of this type the wrong way round, and rotated through 180 degrees from the correct orientation. Getting an integrated circuit the wrong way around is likely to have dire consequences, because the supply pins are usually at opposite corners.

With the device fitted the wrong way round it will be fed with a supply of the wrong polarity. In itself this is unlikely to "zap" a modern semiconductor, but a very high supply current is likely to flow. If this current is maintained for more than a few seconds the device will almost certainly overheat, and it is "par for the course" if an overheated semiconductor explodes with a loud "crack".

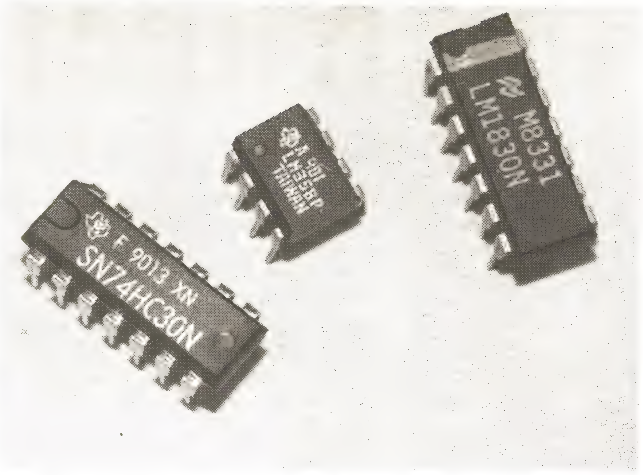

Fig.2. Some chips use only one method of indicating pin one (left and middle) while others use all three (right).

The original method of indicating the correct polarity of an i.c., and one that is still widely used today, is to have a "notch" in what is normally considered to be the top edge of the component, and a "dimple" next to pin one (see Fig.1). When viewed from *above,* the pin numbering runs *anticlockwise.*

In component layout diagrams both the indentation and notch are normally shown, and it is just a matter of orienting the actual component to match up with its representation in the diagram. As a double-check, you can check that the pin one connection agrees with the circuit diagram.

These days it seems to be quite rare for d.i.l. integrated circuits to have both the notch and the dimple, and there is usually only one or the other (see Fig.2). This does not really matter, since either one of them is all that is needed in order to determine the correct orientation for a d.i.l. component.

There is now another method of indicating the top end of the component and pin one, and this is to have a white bar marked across the top of the case (also shown in Fig.2). This method seems to be little used for linear integrated circuits, although it is on the increase. It is used a great deal on logic integrated circuits, particularly the 4000 series CMOS devices.

A few devices have the "belt and braces approach", with the notch, indentation, and white bar all included. Provided at least one of these markings is present there should be no problem in getting a device fitted the right way round.

However, do not be fooled by moulding marks, manufacturer's logos, and other irrelevant markings on the case. These are usually easy to distinguish from the "real thing", but some devices have what at first glance appears to be notches at both ends of the case. Close inspection will reveal that one is the notch and the other is just a moulding mark, which is larger and shallower than the notch.

In Disguise

Not all integrated circuits have d.i.l. encapsulations. The more simple devices, such as many voltage regulators, look like ordinary transistors or power transistors.

Audio power amplifiers often look like outsize power transistors having some extra "legs". The more complex audio power amplifier and voltage regulator chips look like a cross between a d.i.l. integrated circuit and a power transistor.

There are some devices that have a s.i.l. (single in-line) encapsulation. A range of devices that have unusual case styles is shown in Fig.3.

The dimple and (or) notch to identify pin one is retained with some of these more exotic encapsulations, while others have a lack of symmetry that makes it obvious which way round they are fitted. The article concerned should always have diagrams that make the correct orientation of the component perfectly clear.

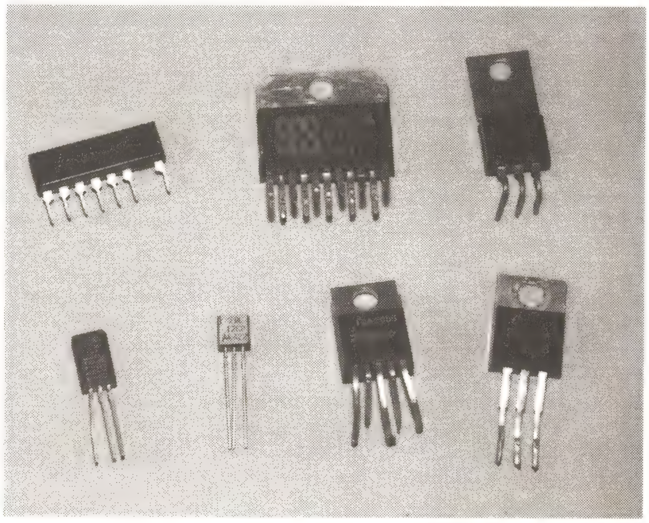

Fig.3. Integrated circuits come in a variety of shapes and sizes.

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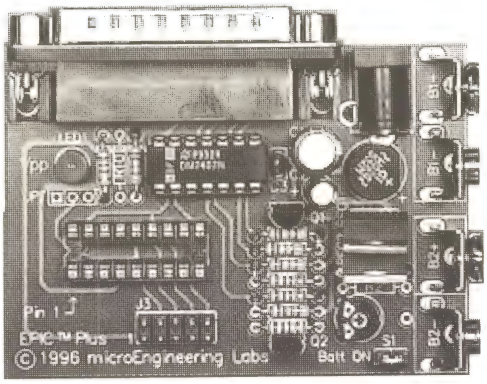

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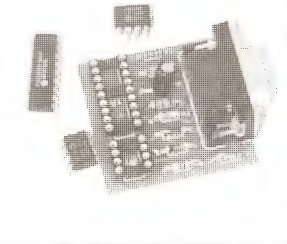

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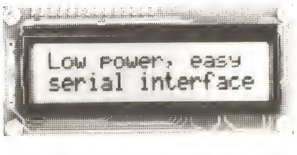

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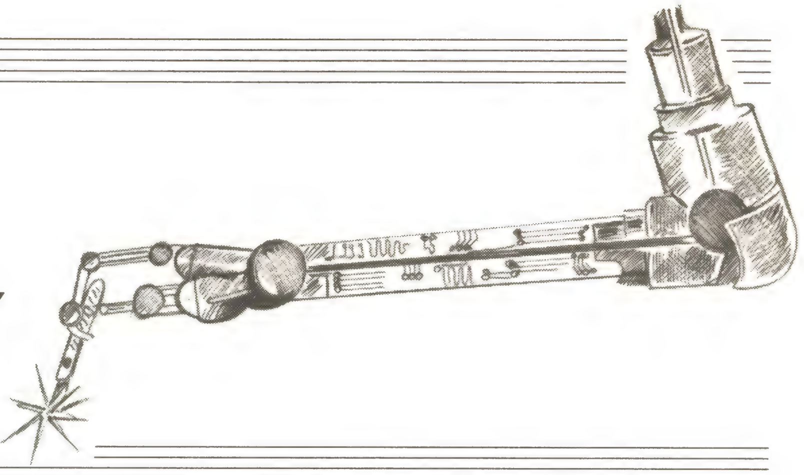


ALAN WINSTANLEY
and IAN BELL

Our team of surgeons examines electrical resistivity, a follow-up on relaxation oscillators and advise on phone or power line suppression.

More Earthly Comments

In your power generation article (September '99) in which you describe mains earthing, cables with armouring usually have a lead sheath which provides the earth path. The lead sheath and armouring are bonded together. You are no doubt aware that copper has a higher conductivity than steel. **L. Hutchinson,** London.

In case readers missed it, we published a two-part article describing power generation and electricity distribution in the August and September '99 issues *(From Pipelines to Pylons)*. The armoured cable photographed on Page 656 (September issue) was assembled before my very eyes by a helpful National Power engineer at the Killingholme "A" power plant.

It seems to be typical of the underground cable used to connect modern houses to the incoming electricity supply. It was sheathed using what was assumed to be a steel braid rather than, say, tinned copper wire. I haven't come across lead sheathed power cables which presumably are used underground, but doubtless any electrical engineers looking in will put me right (please).

I can also testify that even the toughest steel armoured cable couldn't withstand the onslaught of a two-ton fork lift truck: in a previous employment I saw one slice straight through a live steel braided cable when it collided with a factory wall!

Let's examine conductivity a bit more. Any term which ends in "-ivity" relates to the *property of a particular substance*. The *electrical conductivity* of a material determines how effectively it will conduct electric current, and is represented by the Greek sigma symbol σ.

Quite often it is the electrical *resistivity* of a substance which is of interest, a co-efficient which is specified in ohm-metres (Ωm). Resistivity has the Greek symbol ρ (rho) and the lower a material's resistivity, then obviously the better a conductor of electric current it will be. Using this value it is possible to calculate the resistance of, say, a copper conductor if we know its cross-sectional area.

The electrical resistance of a sample of material is given by

$$R = \frac{\rho L}{A}$$

where R is the material's resistance in ohms; ρ is its co-efficient of resistivity in ohm-metres, L is its length in metres and A represents the cross-sectional area of the material in sq. metres, see Fig.1.

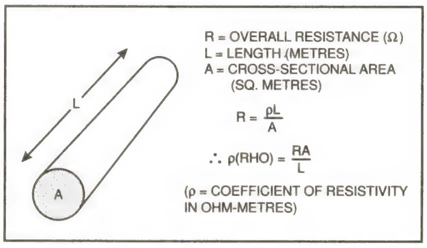

R = OVERALL RESISTANCE (Ω)
L = LENGTH (METRES)
A = CROSS-SECTIONAL AREA (SQ. METRES)
$R = \frac{\rho L}{A}$
$\therefore \rho(\text{RHO}) = \frac{RA}{L}$
(ρ = COEFFICIENT OF RESISTIVITY IN OHM-METRES)
L
A

Fig.1. A conductor of length L and cross-sectional area of A has a resistance which can be calculated using its coefficient of resistivity.

As examples, the resistivity of copper is $1{\cdot}7 \times 10^{-8}$ ohm-metres at room temperature whilst that of Germanium, a semiconductor, is $0{\cdot}5\Omega$m. Quartz has a resistivity of $5 \times 10^{16}\Omega$m which means that it's a very good *insulator*. (You can learn a lot more about the basics of electronics starting this month with our interactive flagship educational series, *Teach-In 2000*, written by John Becker.)

The *conductivity* σ of a material is the inverse or reciprocal of its resistivity: the lower its resistivity then the higher its conductivity will be. Measured in the SI unit of conductance or siemens (S) (formerly mhos – ohms spelt backwards), conductivity is calculated by $1/\rho = 1/RA$. This means that copper has a conductivity of, let's see, $5{\cdot}8 \times 10^{7}$ S m^{-1} and quartz has a conductivity of 2×10^{-17} S m^{-1}. I haven't been able to confirm a value for the resistivity of steel – there are many different grades of steel after all.

Thermal Conductivity

Overhead power lines are usually made of aluminium alloy which is much lighter than its alternatives, so fewer pylons are needed to suspend the cables overhead. The overhead cables are also cooled by winds, which brings me to another coefficient of interest, that of *thermal conductivity*, symbol λ (Lambda). This indicates the ability of a material to conduct heat from a "hot spot" to a surrounding cooler area, so that the temperature differences are ironed out (as it were).

Thermal conductivity properties are of great interest to heatsink manufacturers, who usually extrude aluminium heatsinks in lengths which are then cut to size, punched and anodised. Soldering irons also rely on the principle of thermal conduction to transport heat from the heating element, through the shaft and to the tip, from where it passes to the solder joint. *ARW.*

Oscillator Feedback

Most of the correspondence we receive contains questions for the *Circuit Surgery* team, however, we are also pleased to receive comments and corrections. It is always interesting to hear from readers who have additional insights to problems we have discussed and we will publish these where space permits.

Ian Field from Letchworth, Herts., wrote at length on the subject of the "Lighting-Up Reminder" complimentary oscillator circuit which we discussed in the August 1999 issue. The deceptively simple-looking circuit has a complex operation which has defeated many a designer.

Mr. Field has been producing diverse applications for this circuit for over 30 years and therefore knows the circuit quite well. As a schoolboy he used the circuit, he says, to create a motorcycle sound effect and as a radio jammer (tut-tut!).

He also says that the amber flashing traffic lamps often left by roadworks make use of this circuit, adding:

I cannot remember the exact values. I think that it may have been 1µF or 1µ5 and 2k2 or 4k7 (series resistance with C1). *Resistor R1 was 100k+1M in series with an l.d.r. from the tap down to 0V. The load was a 6V 0·09A lamp. The circuit would oscillate without the use of the resistor in series with the capacitor (C1), but the pulse was so short that the lamp filament* *did not get hot enough to glow with such a short period.*

He says that he finds that oscillation is more stable and reliable if supply decoupling is actually omitted (the lighting-up circuit included it, but we chose to ignore it in our discussion). Mr. Field goes on to say:

As TR2 begins to conduct and switches TR1 into saturation, the charging current taken by C1 will also ensure that the current taken by TR2's collector will force TR1's V_{be} *well over 0·7V. This looks pretty much like an output short circuit to TR2. For this reason, supply decoupling is not only unnecessary, it is unwise.*

It is also my view that the parasitic inductance is not only helpful but essential. There are certain applications in which this circuit simply will not work until the supply decoupling capacitor is removed.

We have not attempted to investigate the effect of supply decoupling or parasitic inductance on this circuit but would be interested to hear from any readers who have had similar (or even contradictory) experiences.

Simulations

Mr. Field also comments on our computer simulation results, in particular he is concerned about the very large value of V_{be} which occurs for a short time each cycle. He was concerned that the transistor would be destroyed and asks if the simulator provided a warning of this.

In fact, large transient voltages and currents often occur in switching circuits. The fact that they are very short in duration means that they do not have sufficient energy to damage the transistors, even when they apparently exceed the data sheet limits.

It is also true to say that simulators may indicate far larger voltages or currents than would actually occur in the real circuit. This can be due to a situation in which a component would be destroyed but also due to use of simplistic models which do not include all the limiting mechanisms.

Our simulation was fairly crude, but it was sufficient for our purpose. We used a generic transistor model (not a particular transistor such as the BC558), the power supply was modelled as an ideal voltage source and no decoupling was included.

This was in line with the aims of the article, that of providing a general understanding of the circuit's operation for people who may find it difficult to understand at all. Our objective was not to analyse the more subtle and detailed aspects of the circuit's behaviour, however, we are extremely grateful to Mr. Field for writing to us on his detailed knowledge of this circuit. *IMB*.

Asta Movistor

Can you think of a circuit which will divert lightning away from modems, by shorting such massive voltages to earth? Alternatively, is there a circuit for an optical isolator which I could use between the phone socket and modem?

Thanks to regular correspondent ***Phil Dodd***. I receive quite a few queries on phone line suppression or modification, but the fact that phone socket modifications are prohibited unless they are BABT approved rules out any form of home-made improvisation. I commented in September's *Net Work*, our Internet column, that Zoom modems carry extra lightning protection together with a five year guarantee.

Any protection is better than none and though it is touch and go whether anything can withstand the intense energy of a lightning strike, you can try to clamp incoming spikes on phone lines or the mains supply. Some modems incorporate MOV (metal oxide varistor) or "Movistor" suppression, see the symbol in Fig.2a.

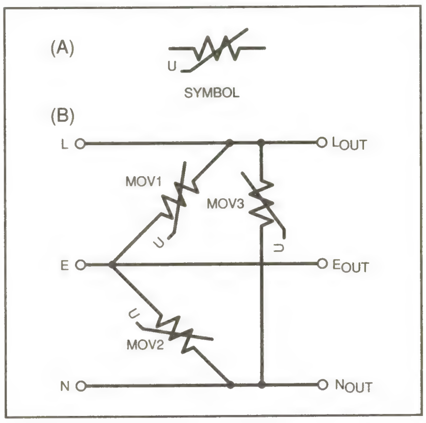


Fig.2. (a) Symbol of a Metal-Oxide Varistor (MOV) and (b) a typical application for a mains-rated varistor.

These voltage-dependent resistors normally have a very high impedance but they will shunt any high energy spikes away, hopefully preventing them from reaching sensitive circuitry. A wide variety is available including some types which are suitable for connection *directly* across the mains, to help avoid spikes damaging electronic equipment.

The company Furse supply "telephone line protectors", and one model is said to be for protecting modems and other equipment with BT jack connections. It's sold by ***Farnell*** (Tel. 01132 636311) part number 188-566 and although it costs £47 + VAT, it is somewhat cheaper than a new motherboard or modem.

For home computer use consider a Belkin Surgemaster Power Strip for susceptible equipment, which has six filtered mains outlets together with a protected BT phone socket as well. It claims to handle 18,000 amps surge current and clamps within one nanosecond. They cost about £30 from *PC World* or *Viking Direct*.

One correspondent has even suggested a form of "lightning early warning system" in the form of an old fluorescent tube, one end of which is connected to a long wire "aerial" outdoors. The tube starts to glow, he suggests, when there is a sufficient electrical charge accumulating in the atmosphere, preceding a possible lightning strike. *ARW*.

Watts Wrong?

Oops! Well spotted, readers! We made a blunder in the article on power output in the September 1999 issue. (Actually it was just a test to see how many of you noticed. *Oh sure – Ed.*) The error was spotted first by ***Mark Daniels*** of Clay Cross, Chesterfield who says:

The r.m.s voltage of a square wave with 50% duty cycle is not $V_{pk}/2$. *We must consider the average power in the load resistor over time to determine the* effective *(or r.m.s.) voltage.*

If we take a square wave with on time t_{on} *and off time* t_{off} *and peak voltage* V_{pk}, *we see that the power into the load resistance, R, is* V^2_{pk}/R. *This is the peak power* P_{pk}. *The average power over the entire cycle is* δP_{pk}, *where* $\delta = t_{on}/(t_{on}+t_{off})$, *so* $P_{rms} = \delta P_{pk}$.

Substituting for P_{rms} *and* P_{pk} *(using* $P=V^2/R$*) we get* $V^2_{rms}/R = \delta V^2_{pk}/\mathrm{R}$. *Hence* $\mathrm{V}^2_{rms} = \delta V^2_{pk}$ *and thus*

$$V_{rms} = \sqrt{\delta V^2_{pk}}$$

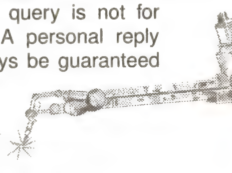
Our mistake was due to an attempt to simplify things that went slightly awry. We were consciously trying to "reason" the result so as to make the article less mathematical but we made a silly error. Trying to avoid the maths was our downfall, the lesson to be learnt here is always use the maths to analyse an electronics problem if it is feasible to do so, never try to side-step it!

In the September *Surgery* the statement that the power for our 50% duty cycle 0V to 12V pulse wave is half that due to 12V d.c. is correct, but the r.m.s. voltage is 8·49V (i.e. $\sqrt{(0{\cdot}5 \times 12^2)}$ using the above formula), not 6V, so the power is 9W not 4·5W (the power of 12V d.c. into 8 ohms is 18W). Still 9W is less than the 11W desired, and Mark agreed with our comment that the general argument in our original article still stood. We will try harder in future, but let us know if you spot any more errors, readers, we might just be testing to see if you are paying attention . . . .

Remember also that PMPO ratings are all but worthless. Alan was recently helping a friend choose a new stereo system, and the Technics unit they settled for had a rating of 70W per channel r.m.s. However, the spec. sheet quoted a PMPO value of (wait for it): . . . 3,000 watts! *IMB*.

CIRCUIT THERAPY

Circuit Surgery is your column. If you have any queries or comments, please write to: Alan Winstanley, *Circuit Surgery*, Wimborne Publishing Ltd., Allen House, East Borough, Wimborne, Dorset, BH21 1PF, United Kingdom. E-mail **alan@epemag.demon.co.uk**. Please indicate if your query is not for publication. A personal reply cannot always be guaranteed but we will try to publish representative answers in this column.



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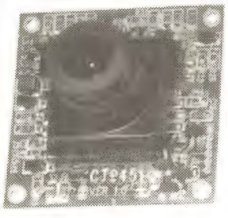

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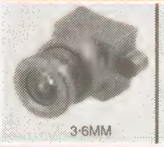

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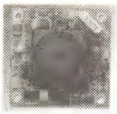

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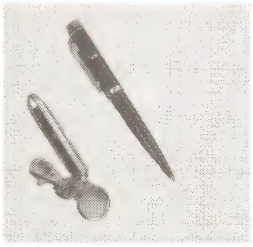

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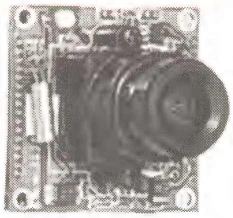

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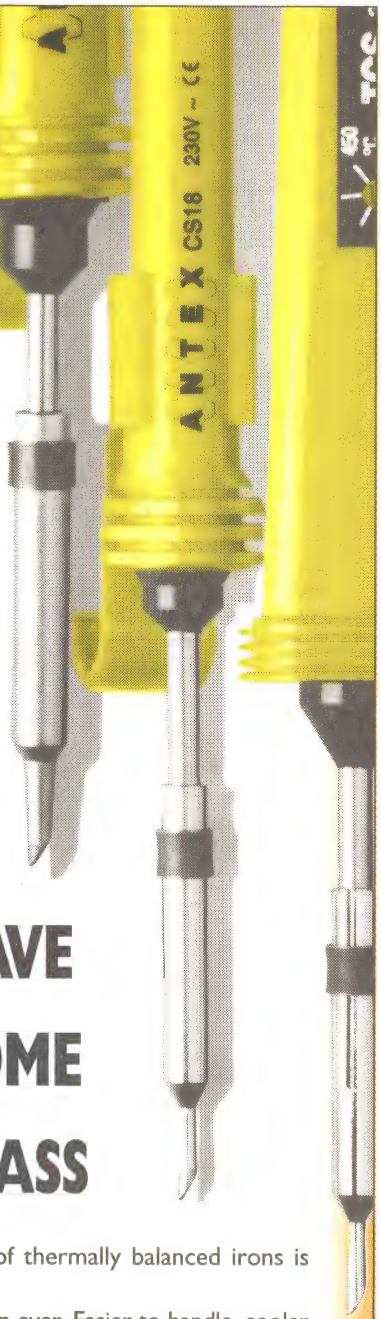

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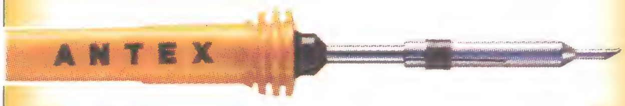

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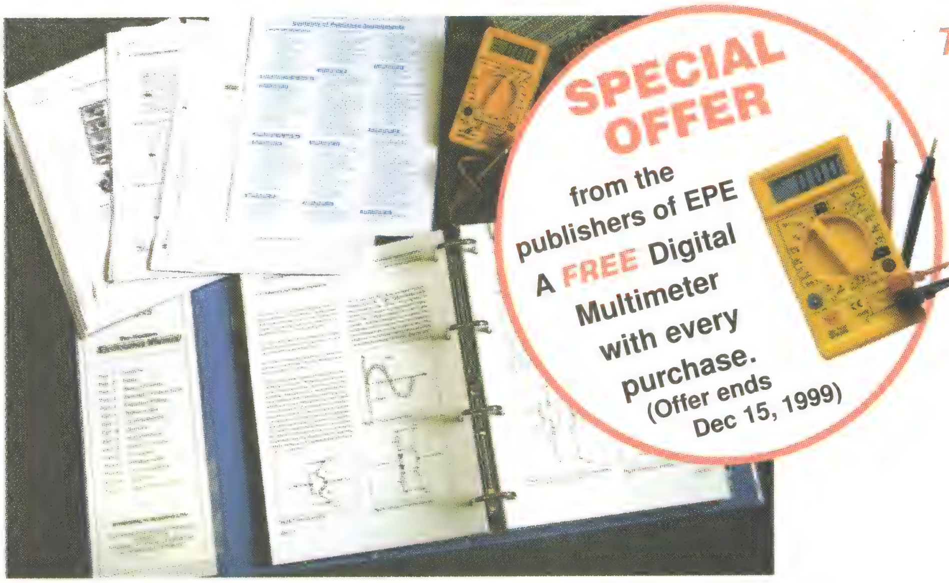

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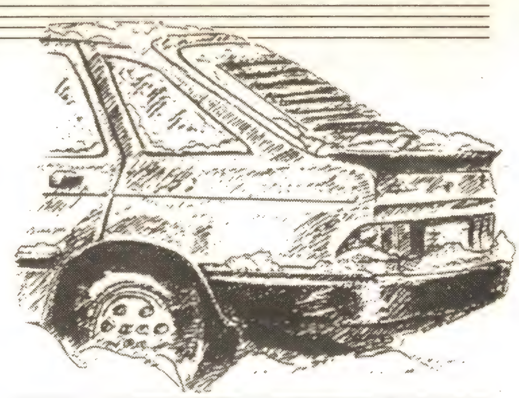

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Join the luxury set! Switches off your heated rear windscreen automatically

How many times have you used your car demister and forgotten to switch it off? Lost count?

This means that the next time you switch on the ignition, the rear windscreen will warm up whether you need it to or not. The warning light usually found in the switch is not much help and is easily missed.

SWITCH OFF

A typical demister requires 12A approximately and will be even more in cars having a large rear windscreen. For example, the resistance of the heater element in a Renault *Clio* was measured and found to be 0·9 ohms corresponding to about 13A or some 150 watts on the nominal 12V system.

If you have the headlights switched on too plus a few of the high-current devices which seem to have become part of modern motoring, this imposes a considerable load on the car charging system. In extreme cases, it can exceed the output of the alternator. The battery will then run down at a rate needed to make up the difference.

This problem will be compounded if you do a lot of "start-stop" driving where the starter motor is used excessively. Believe it or not, there are some people who leave their demister switched on right through the winter so that it will always operate while the ignition is on!

NOT FOR TURNING

A large electrical load on the alternator will make its pulley harder to turn. So much so that the fan belt may slip and fail to transmit the drive properly. This can occur even with a correctly-tensioned fan belt and is aggravated by grease and dust collecting on its running surface. This will make the problems mentioned earlier much worse.

Using high-current electrical equipment significantly increases fuel consumption. This is because it is the fuel which provides the energy to generate all that electricity in the first place! For all these reasons, it makes sense to use the heated rear windscreen sparingly and only for as long as it takes to have the intended effect.

Some vehicles have a demister timing circuit already provided. However, most people have cars which are not so equipped. It is then left up to the driver to switch off manually when the rear windscreen has cleared.

OVERVIEW

The Demister One-Shot described here is an easy-to-build add-on circuit which puts the heated rear windscreen under automatic control. On pressing a pushbutton switch, the heating element operates for some preset time between 6 and 50 minutes approximately then switches off.

While it is on, an l.e.d. (light-emitting diode) glows to confirm this. If the button is pressed again during the course of operation, it will switch off. Another cycle may then be initiated by pressing it again.

The main unit is built in a small plastic box (see photograph) which is secured under the dashboard out of sight. A separate small panel having the switch and l.e.d. mounted on it is placed in a convenient position for the driver to operate (see photograph).

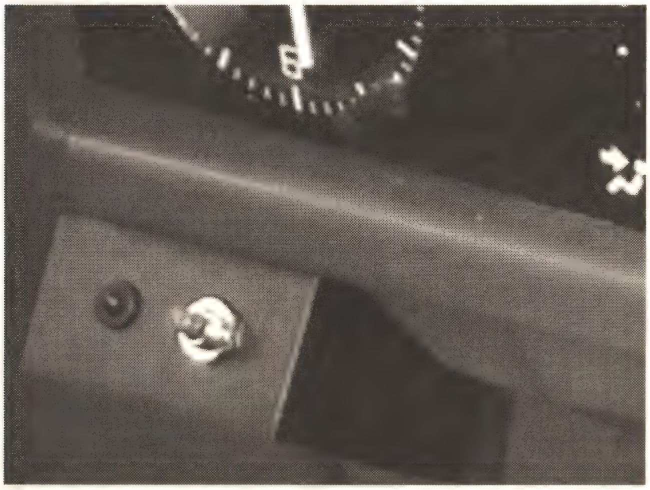
It would also be possible to site the switch and l.e.d. on the front of the main unit. However, although it would avoid some wiring, the profile of the box would be rather large and it would not present a good appearance.

The switch panel and main unit are interconnected using a piece of 4-core light-duty wire. A piece of screw terminal block on the p.c.b. (printed circuit board) inside the main unit is used to make the connections to the existing circuit. The unit requires only 1·3mA approximately while on standby.

INITIAL CHECKS

Before proceeding, we need to make some initial checks. A typical heated rear windscreen circuit is shown in Fig.1. Note that this is a simplified diagram and does not show, for example, the warning light which is usually built into the on-off switch.

A relay is normally used to do the job of actually directing current to the rear screen element via a high current rating fuse. The dashboard-mounted switch then only needs



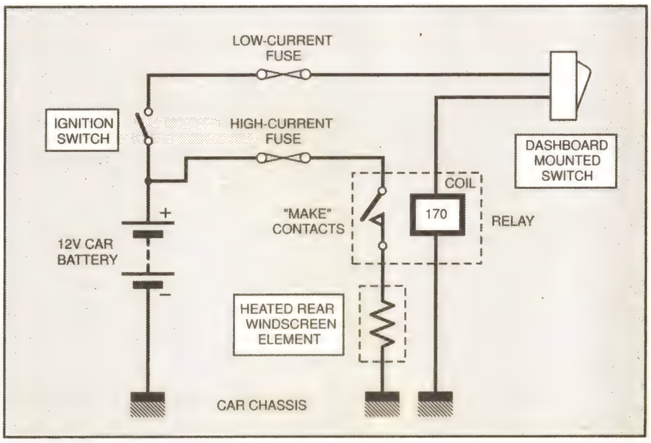


Fig.1. Typical heated rear windscreen circuit arrangement.

to carry the small relay coil current (which arrives via the ignition switch and a fuse of low current rating) so it may be of a compact light-duty type.

Some cars may possibly have a switch which carries current ***direct*** from the supply to the element – that is, without the use of a relay. The other end of the windscreen element is grounded ("earthed") to the chassis of the car to complete the circuit.

CIRCUIT DESCRIPTION

The full circuit diagram for the Demister One-Shot is shown in Fig. 2. IC1 is a timer integrated circuit of a type specially manufactured for automotive applications. It is thus designed to be practically immune from false triggering due to random pulses which may appear on the supply lines. Also, it will not trigger on powering-up which can sometimes happen in circuits of this type.

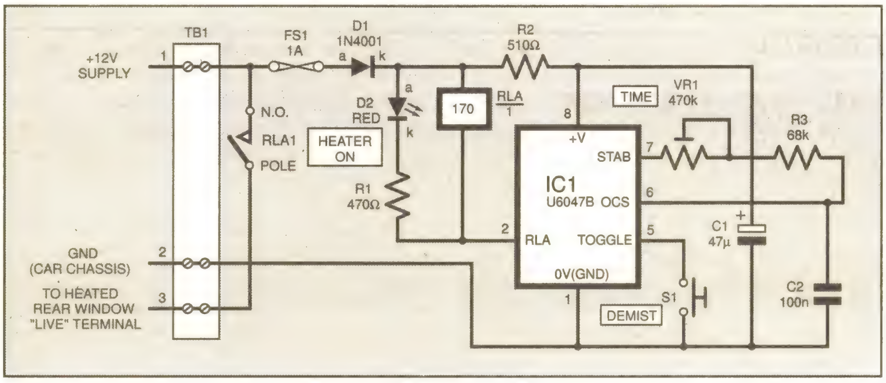


Fig.2. Complete circuit diagram for the rear screen Demister One-Shot.

Car charging circuits are notoriously "noisy" with the alternator providing a very unsmooth supply. High-voltage spikes often appear in the wiring at random and when high-current inductive equipment is switched off, these effects can cause spurious operation or false re-setting when ordinary i.c.s are used. They can even ruin an i.c.

Another point is that when a high-current device is switched on, there is a sudden fall in supply voltage (due to the voltage drop across the resistance of the wiring). This can also cause false re-setting (switching off). However, such problems do not occur in this circuit.

With the specified i.c., much of the necessary circuitry is fabricated on the chip so the external component count is kept to a minimum. A 12V supply from the existing circuit is connected (via terminal block TB1/1) through fuse FS1 and diode D1 to the new circuit.

The diode D1 gives reverse-polarity protection since, if the supply were to be applied in the wrong sense, it would fail to conduct and nothing would happen. The fuse FS1 is included to guard against any unlikely failure of the circuit resulting in a short-circuit to the supply.

Power is applied to IC1 pin 8 via the network consisting of resistor R2 and capacitor C1 which smoothes the supply and removes much of the line noise mentioned earlier. There is also an inbuilt 14V Zener diode connected between pin 8 and pin 1 (connected to 0V). This normally does nothing but serves to protect the i.c. from spikes greater in voltage than 14V because the diode would conduct and bypass them.

TIME DELAY

The time delay aspect of the circuit works like this. The resistance appearing between IC1 pin 6 and pin 7 (*R*) operates in conjunction with the capacitance between pin 6 and the 0V line (*C*) to set the frequency (*f*) of an on-chip oscillator.

The minimum allowed values of *C* and *R* (1n and 59k) will provide the highest frequency (about 20kHz) while the maximum ones (4μ7 and 280k) will give the lowest – about 1Hz. The frequency may therefore be set to any value between these limits by a suitable choice of components.

One cycle of the oscillator will take the time, *T*, given by 1/*f* and will be 0·05ms at a frequency of 20kHz and one second at 1Hz. On the first pulse of the oscillator, IC1 output (pin 2) will go low. An internal counter then "clocks up" the total number of cycles until 73728 have been registered whereupon the i.c. times out and pin 2 reverts to its former state. The formula for the delay time (*T*) is therefore given by:

$$T = 73728 \times 1/f.$$

With the highest and lowest values of *C* and *R*, this gives upper and lower limits of 20 hours and 4 seconds approximately. Of course, this range is far too great for the present application. The advantage of using a large number of cycles is that the value of *C* can be kept low and this reduces the size and cost of the finished circuit.

TIME ADJUSTMENT

It is necessary to provide an adjustment so that the timing may be preset to suit individual requirements. For this reason, *R* comprises preset potentiometer VR1 connected in series with fixed resistor R3. The timing capacitor is C2 and this is fixed in value.

With VR1 set to minimum, the period will be some 6 minutes and when at maximum, about 50 minutes. This range of values will be found satisfactory for most purposes. However, the timing could be extended by increasing the value of capacitor C2 as required.

The output at IC1 pin 2 takes the form of a Darlington driver. This is designed to operate the coil of a fairly substantial relay direct. In fact, the output will supply up to 300mA approximately although, here, the coil of relay RLA requires only some 70mA.

Note that no external diode is connected across the relay coil as is normal practice. This is because a diode (in fact it is a 23V Zener diode) is already fabricated on the chip. This protects the i.c. from the reverse high-voltage pulse which appears across the coil when the magnetic field in the core collapses on switching off. When this happens, the diode conducts and bypasses it.

Light-emitting diode D2, together with series resistor R1, are connected in parallel with the relay coil. The l.e.d. therefore glows while the coil is drawing current and serves to show that the circuit is timing. Resistor R1 limits its operating current to about 20mA.

While the relay is energised, its normally-open ("make") contacts close and direct current from the +12V feed (at terminal block TB1/1), via the existing high-current fuse, to the "live" side of the heated rear windscreen (connected to TB1/3).

Pins 3 and 4 (internal switch) of IC1 could be connected to 0V via pushbutton switches to perform separate *on* and *off* functions respectively instead of using toggle operation (press on, press off). However, there seems no point in using two switches instead of one and these pins are left unconnected.

Pin 5 of IC1 is the toggle input and may be made low momentarily by operating

COMPONENTS

See SHOP TALK page

Resistors

R1	470Ω
R2	510Ω
R3	68k

All 0·25W 5% carbon film

Potentiometer

VR1	470k sub min. enclosed carbon preset, vertical

Capacitors

C1	47µ radial elect. 25V.
C2	100n metallised polyester – 2·5mm pin spacing

Semiconductors

D1	1N4001 50V 1A rect. diode.
D2	3mm red l.e.d.
IC1	U6047B automotive-type timer i.c.

Miscellaneous

RLA	12V 170 ohm coil automotive-type relay, with single-pole changeover contacts rated at 16A minimum
FS1	1A sub-min. axial fuse.
S1	miniature push-to-make switch.
TB1	3-way section of p.c.b. screw terminal block (10mm pin spacing) rated at 16A minimum.

Printed circuit board available from the *EPE PCB Service*, code 245; plastic box, size 97mm x 73mm x 39·5mm for main unit; potting box, size 38mm x 38mm x 19mm, for the switch panel or small bracket (see text); 8-pin d.i.l. socket; 16A minimum auto-type multistrand wire; 3A auto-type wire; auto-type e.g. "bullet" connectors – 16A rating minimum; 18s.w.g. tinned copper wire; 3mm l.e.d. clip; light-duty 4-core stranded wire; connecting wire; solder, etc.

Approx. Cost Guidance Only **£14**
excl. auto-cable & boxes

pushbutton switch S1. With each press, the circuit will alternate between "timing" and "off".

DEBOUNCING

The contacts of a mechanical switch bounce as they close. That is, they repeatedly "break" and "make" a few times until they settle down to a closed state.

This could present a problem with S1 because, on operating it, pin 5 would go low several times in rapid succession. The first low state to arrive would trigger the circuit, the second would cancel it and so on. Whether the i.c. was ultimately left in a set (on) or re-set (off) condition would therefore be unpredictable.

To avoid this problem, the switch is "debounced" using the internal oscillator. Thus, only the low state arriving on the first cycle will have any effect. The circuit will then be inactive for a short time so that any further pulses will not be "seen".

This allows the contacts to settle down. The inactive time is very short (about six oscillator cycles) so the unit will respond correctly when the switch is operated again.

While the circuit is timing, the normally-open ("n.o.") contact (RLA1) of the relay is "made" (closed) and provides a +12V feed to the non-earthed terminal of the heated rear windscreen or possibly short-circuit the existing switch (more will be said about this later). The existing switch will not be used and it would be a good idea to tape it over, so that it cannot be operated inadvertently. If this was done, the demister would heat up irrespective of the status of the new circuit.

CONSTRUCTION

Construction of the main unit is based on a single-sided printed circuit board (p.c.b.). The component layout and full-size copper foil master are shown in Fig. 3. This board is available from the *EPE PCB Service*, code 245. It will be noted that all the components are mounted on this except switch S1 and l.e.d. D2 which are sited on a separate panel or small plastic box.

Begin construction with the p.c.b. Drill the three mounting holes and then solder the i.c. socket in position (but do not insert the i.c. yet). This should be followed by the three-way piece of screw terminal block and the relay. Next, the resistors (including preset VR1) and capacitor C2 can be added.

Solder fuse FS1 in place. Note that the specified, axial lead, fuse is a sub-miniature type designed to be soldered *directly* on the p.c.b. This is convenient because, in practice, it is unlikely ever to blow. However, some readers may wish to use a separate chassis fuseholder instead with its wires soldered to the "FS1" pads.

Finally, add capacitor C1 and diode D1 taking care to observe the polarity of these components. Adjust VR1 fully clockwise (as viewed form the top edge of the p.c.b.) to give minimum timing which will be best for testing purposes.

REINFORCEMENTS NEEDED

Depending on how the unit will be connected to the existing system, the relay contacts will possibly need to carry the ***full*** demister operating current and it will be necessary to re-inforce the copper sections of p.c.b. track between the normally-open (n.o.) contacts and the terminal block pins (shown by cross-hatching in Fig.3). This should be done by soldering pieces of 20s.w.g. (or thicker) tinned copper wire along their length.

This is necessary because the tracks will not be capable of carrying the high current needed to operate the windscreen heater element. Without re-inforcement they would overheat and could possibly melt. Reinforcement is always necessary where a direct +12V feed is made to the heater element.

Some readers may prefer to use the relay contacts in the new unit simply to bypass the present switch. Assuming there is an existing relay, there would be no need to re-inforce the tracks because they would only carry the current for its coil.

This method is not really ideal because there would now be two relays in the circuit and this would introduce an element of unreliability. However, it does have the advantage that the wiring may be easier to carry out since you only need to gain access to the existing switch tags. More will be said about this later.

BOX PREPARATION

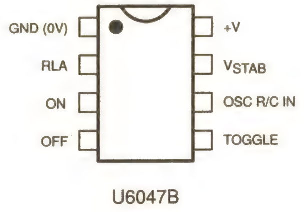
Prepare the plastic box for the p.c.b. by marking the mounting holes on the bottom and drilling these. Drill a hole in the rear, close to the l.e.d. "D2" and pushswitch "S1" points on the p.c.b. This will allow the wires to pass through to the panel. Drill a larger hole near to the terminal block TB1 position for the wires passing through to the car system.

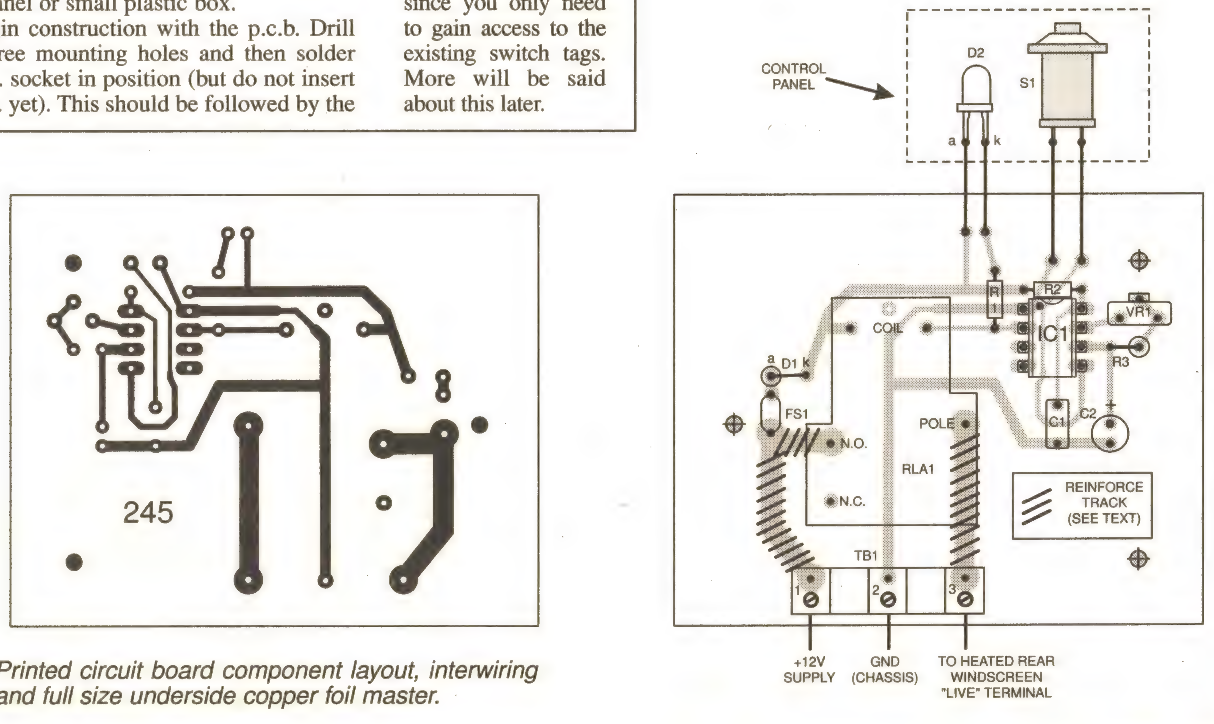
Decide on suitable positions for the main unit and switch panel. These should be fairly close together so that the length of the inter-connecting lead is 20cm maximum. Cut off a piece of light-duty 4-core stranded wire to reach between the two.

If *stranded* 4-core wire is not available, use two pieces of 2-core. Note that suitable 4-core wire is available as "burglar alarm cable" but take care that it is not of the solid-core type (often sold as "telephone cable") which would break easily in service.

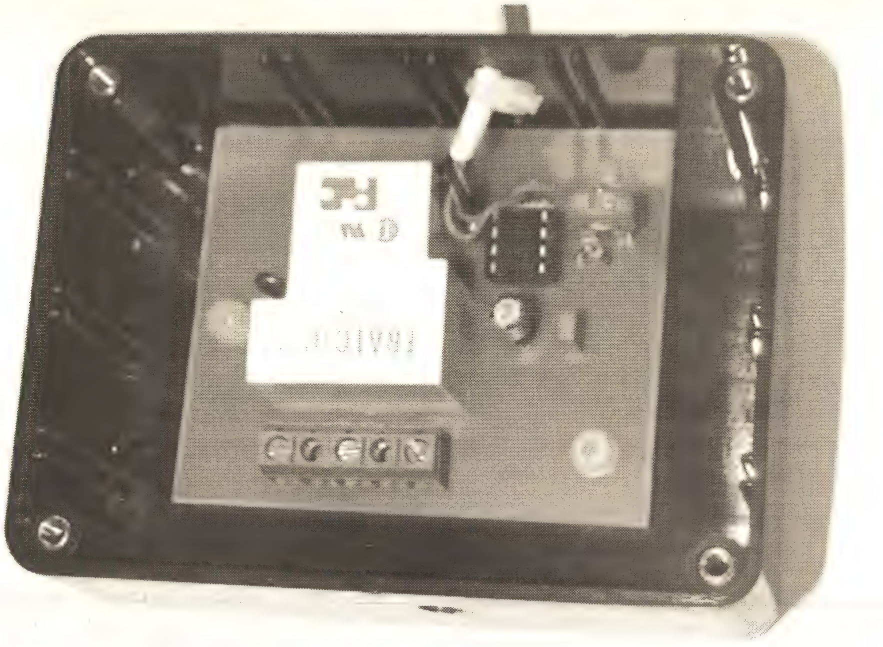
Pass one end of the wire through the hole and solder the ends to the D2 and S1 points on the p.c.b., see Fig.3. Make a careful note of which wire is which and, particularly, which one is for the l.e.d. anode (a) and which for the cathode (k).

Attach the p.c.b. using short spacers on the bolt shanks to keep the copper track side clear of the bottom of the box. Leaving a little slack in the wire on the inside, apply a small cable clamp or a tight cable tie to the wire to provide strain relief.





Printed circuit board component layout, interwiring and full size underside copper foil master.



Completed circuit board mounted inside the main unit box. Use nylon nuts and bolts with suitable spacers. You must use heavy-duty automotive wire for connections from the terminal block.

SWITCH PANEL

In the prototype unit, the switch panel was made using a "potting box", size 38mm × 38mm × 19mm approx. However, many readers will have their own ideas about how this should be constructed.

A small car-type accessory bracket could be used providing it is large enough to accommodate the l.e.d. and switch. It would also be possible to make your own bracket using sheet aluminium sprayed in a suitable colour.

Another idea would be to utilise the blanking plate often fitted to unoccupied switch positions. Whatever method is used, make sure the connections to the switch and l.e.d. are *insulated* so that no metal parts can touch them.

Assuming a small box (such as a potting box) is used, drill holes for the l.e.d. clip and switch also a hole in a side panel for the leadout wire to pass through. Mount these components and pass the free end of the wire through the hole.

Solder the ends of the wires to the l.e.d. and switch taking care that the correct wire is connected in each case. Note that the anode (a) l.e.d. wire is connected to the *longer* end wire. Leaving a little slack, clamp the wire as in the main unit so that it cannot pull free in service.

TESTING

Testing the finished unit is best carried out using a 9V battery. In this way, any problems may be resolved before connecting the circuit to the car system. Note that, although a 9V supply will be sufficient to operate the circuit, it will probably not make the relay click over.

However, operation may be monitored by observing the l.e.d. Insert IC1 into its socket. Since it is a bipolar device, it does not require any special handling precautions.

Referring to the wiring diagram of Fig.3, connect terminal TB1/1 (+12V feed) and TB1/2 (chassis) on the p.c.b. to the positive and negative battery terminals respectively. Press the Demist switch S1 and note that the l.e.d. comes on.

After about six minutes (this is subject to quite a wide variation), it should go off again. Re-trigger and press the button again before the end of the natural time-out period. The l.e.d. should go off immediately.

If this basic test works, it is likely that the circuit will operate correctly when connected to the car system. Adjust preset VR1 to approximately mid-track position.

CONNECTING UP

The next stage is to install the two units in the vehicle. Remove the fuse which protects the heated rear windscreen and check that the circuit is "dead". This fuse will be rated at, say, 16A. Do not confuse it with any low-current fuse used in the relay coil circuit or elsewhere. Make small brackets to attach the units, route the inter-connecting wire as required and attach the control panel but do not secure the main unit yet.

Decide on how the unit is to be connected to the car system. If you follow the method used in the prototype, you will need to pick up the high-current +12V feed for the existing circuit at a convenient point between the "live" relay "make" contact and the fuse. If convenient, you could make the connection at the relay itself using the appropriate connector.

Do not connect to any other circuit and do not use any low-current connection to the coil of an existing relay. On no account, wire the unit so that the full heater operating current flows through the ignition switch unless it has been designed for such use – it would be destroyed.

Using automotive wire of 16A rating *minimum,* make the connection to TB1/1. Another connection will need to be made to the "live" (non-earthed) side of the rear screen heater element. You will be able to make this between the relay contact and element or, of course, at the relay itself. This wire is connected to TB1/3.

For all this wiring, use proper automotive (for example, "bullet" type) connectors of appropriate rating. Note also that if any wire needs to pass through a hole in metal, it must be protected using a plastic grommet.

As mentioned earlier, you could possibly use the relay contacts in the new circuit simply to bypass the original rear screen heater switch. Check that there is a +12V supply at one terminal of the switch which is obtained via a low-value fuse.

Assume for the moment that there is an existing relay. Using the appropriate connectors, obtain a +12V feed from the live side of the switch and connect it to TB1/1. Connect the terminal of the switch which leads to the relay coil to TB1/3.

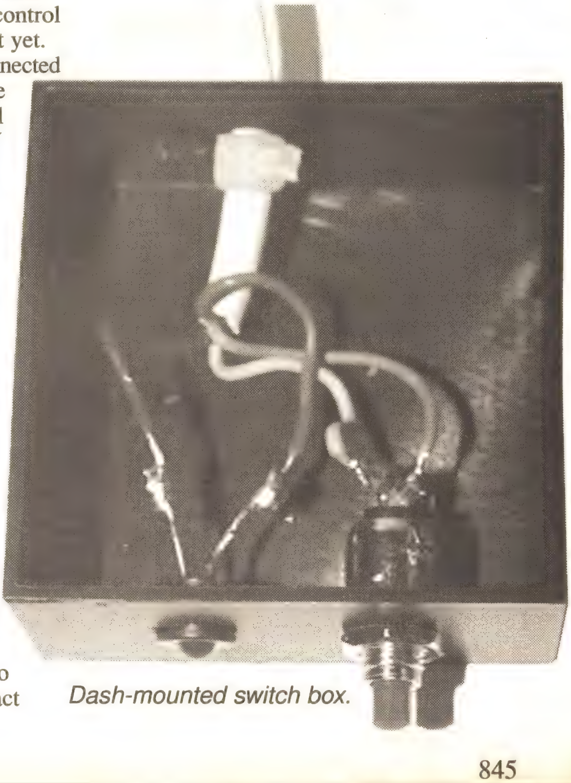
Since the wiring only needs to carry the current for the relay coil, you could use light-duty type (say, 3A rating) but note that it ***must*** still be of the proper automotive type. If there is no existing relay, this method will still work but make sure that the p.c.b. tracks have been re-inforced as described earlier. Also, the connections must be made with wire of ***16A rating minimum***.

Cut a piece of wire (which may be of 3A automotive type) for the "ground" (car chassis) connection. Make this long enough to reach a nearby metal earth/chassis point. Connect this to terminal TB1/2. Leaving a little slack in all the wires, clamp them inside the box so that they cannot pull free in use.

ON THE ROAD

Secure the main unit in position. Replace the high current fuse, switch on the ignition and press the Demist switch S1. The Heater l.e.d. should come on and the demister operate. Cancel before the battery runs down significantly.

On a test drive, try it for the set time. All that remains is to determine the best operating period and adjust preset VR1 over a period of a few days for best effect. □



Dash-mounted switch box.

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EX-GPO SPEAKER INSERTS. Ref 4T. Pack of 2. Order Ref: 352.
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SKIRTED CONTROL KNOBS. Engraved 0-10, pack of 4. Order Ref: 355.
LUMINOUS PUSH-ON PUSH-OFF SWITCHES. Pack of 3. Order Ref: 373.
MAINS TRANSFORMER OPERATED NICAD CHARGER. Cased with leads. Order Ref: 385.
CLOCKWORK MOTORS. Run for one hour. Order Ref: 389.
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SPECIAL PRICE FOR TWO MONTHS
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LIGHT ALARM. A circuit for this appears in the February issue. however, we have a rather less complicated model already made up and in a nice case. Price only £3. Order Ref: 3P155.
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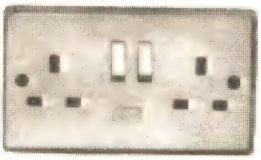

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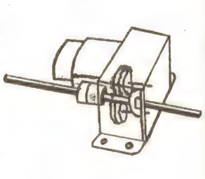

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BOOK OF THE MONTH

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HOW ELECTRONIC THINGS WORK . . . and what to do when they don't
Robert Goodman

At some time or another, almost every household electronic product, be it your VCR, your PC, or your cellular phone, will experience some type of glitch. Many of the so-called extensive repairs made by high-priced repair shops actually involve adjusting a few components or replacing a few cheap parts. Other times the problem is beyond the average do-it-yourselfer, and an expert is required. The trick is knowing how and when to perform the repair yourself, and when to call in the pros. This book will provide the do-it-yourselfer with a heavily illustrated guide to performing basic troubleshooting and repair on the most common electronic equipment, safely and cost-effectively. This is an American publication.

- ★ Provides a basic introduction to troubleshooting and safety requirements.
- ★ Provides a brief overview, easy-to-use schematics and photographs for each of the most common household devices.
- ★ Written for a novice do-it-yourselfer and assumes no prior troubleshooting and repair experience.
- ★ Contains the most common problems and solutions for each device discussed.

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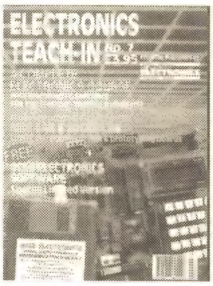

TEACH-IN No. 7. plus FREE SOFTWARE
ANALOGUE AND DIGITAL ELECTRONICS COURSE
(published by *Everyday Practical Electronics*)
Alan Winstanley and Keith Dye B.Eng(Tech)AMIEE

This highly acclaimed *EPE Teach-In series, which included the construction and use of the Mini Lab* and *Micro Lab* test and development units, has been put together in book form. Additionally, EPT Educational Software have developed a GCSE Electronics software program to compliment the course and a **FREE DISK** covering the first two parts of the course is included with the book.

An interesting and thorough tutorial series aimed specifically at the novice or complete beginner in electronics. The series is designed to support those undertaking either GCSE Electronics or GCE Advanced Levels, and starts with fundamental principles.

If you are taking electronics or technology at school or college, this book is for you. If you just want to learn the basics of electronics or technology you must make sure you see it. *Teach-In No. 7* will be invaluable if you are considering a career in electronics or even if you are already training in one. The Mini Lab and software enable the construction and testing of both demonstration and development circuits. These learning aids bring electronics to life in an enjoyable and interesting way: you will both see and hear the electron in action! The Micro Lab microprocessor add-on system will appeal to higher level students and those developing microprocessor projects.

160 pages Order code TI7 **£3.95**

The books listed have been selected by *Everyday Practical Electronics* editorial staff as being of special interest to everyone involved in electronics and computing. They are supplied by mail order to your door. Full ordering details are given on the last book page.

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RADIO / TV VIDEO

ELECTRONIC PROJECTS FOR VIDEO ENTHUSIASTS
R. A. Penfold

This book provides a number of practical designs for video accessories that will help you get the best results from your camcorder and VCR. All the projects use inexpensive components that are readily available, and they are easy to construct. Full construction details are provided, including stripboard layouts and wiring diagrams. Where appropriate, simple setting up procedures are described in detail; no test equipment is needed.

The projects covered in this book include: Four channel audio mixer, Four channel stereo mixer, Dynamic noise limiter (DNL), Automatic audio fader, Video faders, Video wipers, Video crispener, Mains power supply unit.

109 pages Order code BP356 **£4.95**

SETTING UP AN AMATEUR RADIO STATION
I. D. Poole

The aim of this book is to give guidance on the decisions which have to be made when setting up any amateur radio or short wave listening station. Often the experience which is needed is learned by one's mistakes, however, this can be expensive. To help overcome this, guidance is given on many aspects of setting up and running an efficient station. It then proceeds to the steps that need to be taken in gaining a full transmitting licence.

Topics covered include: The equipment that is needed; Setting up the shack; Which aerials to use; Methods of construction; Preparing for the licence.

An essential addition to the library of all those taking their first steps in amateur radio.

86 pages Order code BP300 **£3.95**

EXPERIMENTAL ANTENNA TOPICS
H. C. Wright

Although nearly a century has passed since Marconi's first demonstration or radio communication, there is still research and experiment to be carried out in the field of antenna design and behaviour.

The aim of the experimenter will be to make a measurement or confirm a principle, and this can be done with relatively fragile, short-life apparatus. Because of this, devices described in this book make liberal use of cardboard, cooking foil, plastic bottles, cat food tins, etc. These materials are, in general, cheap to obtain and easily worked with simple tools, encouraging the trial-and-error philosophy which leads to innovation and discovery.

Although primarily a practical book with text closely supported by diagrams, some formulae which can be used by straightforward substitution and some simple graphs have also been included.

72 pages Order code BP278 **£3.50**

25 SIMPLE INDOOR AND WINDOW AERIALS
E. M. Noll

Many people live in flats and apartments or other types of accommodation where outdoor aerials are prohibited, or a lack of garden space etc. prevents aerials from being erected. This does not mean you have to forgo shortwave listening, for even a 20-foot length of wire stretched out along the skirting board of a room can produce acceptable results. However, with some additional effort and experimentation one may well be able to improve performance further.

This concise book tells the story, and shows the reader how to construct and use 25 indoor and window aerials that the author has proven to be sure performers.

Much information is also given on shortwave bands, aerial directivity, time zones, dimensions etc.

50 pages Order code BP136 **£1.75**

PROJECT CONSTRUCTION

PRACTICAL REMOTE CONTROL PROJECTS
Owen Bishop

Provides a wealth of circuits and circuit modules for use in remote control systems of all kinds; ultrasonic, infra-red, optical fibre, cable and radio. There are instructions for building fourteen novel and practical remote control projects. But this is not all, as each of these projects provides a model for building dozens of other related circuits by simply modifying parts of the design slightly to suit your own requirements. This book tells you how.

Also included are techniques for connecting a PC to a remote control system, the use of a microcontroller in remote control, as exemplified by the BASIC Stamp, and the application of ready-made type-approved 418MHz radio transmitter and receiver modules to remote control systems.

160 pages Order code BP413 **£5.99**

PRACTICAL ELECTRONIC MODEL RAILWAY PROJECTS
R. A. Penfold

The aim of this book is to provide the model railway enthusiast with a number of useful but reasonably simple projects that are easily constructed from readily available components. Stripboard layouts and wiring diagrams are provided for each project. The projects covered include: constant voltage controller; pulsed controller; pushbutton pulsed controller; pulsed controller with simulated inertia, momentum and braking; automatic signals; steam whistle sound effect; two-tone horn sound effect; automatic two-tone horn effect; automatic chuffer.

The final chapter covers the increasingly popular subject of using a computer to control a model railway layout, including circuits for computer-based controllers and signalling systems.

151 pages Order code BP384 **£4.99**

A PRACTICAL INTRODUCTION TO SURFACE MOUNT DEVICES
Bill Mooney

This book takes you from the simplest possible starting point to a high level of competence in handworking with surface mount devices (SMD's). The wider subject of SM technology is also introduced, so giving a feeling for its depth and fascination.

Subjects such as p.c.b. design, chip control, soldering techniques and specialist tools for SM are fully explained and developed as the book progresses. Some useful constructional projects are also included.

Whilst the book is mainly intended as an introduction, it is also an invaluable reference book, and the browser should find it engrossing.

120 pages Order code BP411 **£4.99**

FAULT-FINDING ELECTRONIC PROJECTS
R. A. Penfold

Starting with mechanical faults such as dry joints, short-circuits etc, coverage includes linear circuits, using a meter to make voltage checks, signal tracing techniques and fault finding on logic circuits. The final chapter covers ways of testing a wide range of electronic components, such as resistors, capacitors, operational amplifiers, diodes, transistors, SCRs and triacs, with the aid of only a limited amount of test equipment.

The construction and use of a Tristate Continuity Tester, a Signal Tracer, a Logic Probe and a CMOS Tester are also included.

136 pages Order code BP391 **£4.99**

TEST EQUIPMENT CONSTRUCTION
R. A. Penfold

This book describes in detail how to construct some simple and inexpensive but extremely useful, pieces of test equipment. Stripboard layouts are provided for all designs, together with wiring diagrams where appropriate, plus notes on construction and use.

The following designs are included:–

AF Generator, Capacitance Meter, Test Bench Amplifier, AF Frequency Meter, Audio Mullivoltmeter, Analogue Probe, High Resistance Voltmeter, CMOS Probe, Transistor Tester, TTL Probe.

The designs are suitable for both newcomers and more experienced hobbyists.

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HOW TO DESIGN AND MAKE YOUR OWN P.C.B.s
R. A. Penfold

Deals with the simple methods of copying printed circuit board designs from magazines and books, and covers all aspects of simple p.c.b. construction including photographic methods and designing your own p.c.b.s.

66 pages Order code BP121 **£3.99**

ELECTRONIC PROJECT BUILDING FOR BEGINNERS
R. A. Penfold

This book is for complete beginners to electronic project building. It provides a complete introduction to the practical side of this fascinating hobby, including the following topics:

Component identification, and buying the right parts; Resistor colour codes, capacitor value markings, etc; Advice on buying the right tools for the job; Soldering, with advice on how to produce good joints and avoid "dry" joints; Making easy work of the hard wiring; Construction methods, including stripboard, custom printed circuit boards, plain matrix board, surface mount boards and wire-wrapping; Finishing off, and adding panel labels; Getting "problem" projects to work, including simple methods of fault-finding; In fact everything you need to know in order to get started in this absorbing and creative hobby.

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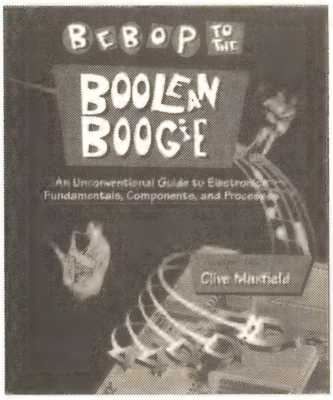
BEBOP TO THE
BOOLEAN BOOGIE
An Unconventional Guide to Electronics Fundamentals, Components, and Processes
Clive Maxfield

This book gives the "big picture" of digital electronics. This indepth, highly readable, up-to-the-minute guide shows you how electronic devices work and how they're made. You'll discover how transistors operate, how printed circuit boards are fabricated, and what the innards of memory ICs look like. You'll also gain a working knowledge of Boolean Algebra and Karnaugh Maps, and understand what Reed-Muller logic is and how it's used. And there's much, MUCH more (including a recipe for a truly great seafood gumbo!).

Hundreds of carefully drawn illustrations clearly show the important points of each topic. The author's tongue-in-cheek British humor makes it a delight to read, but this is a REAL technical book, extremely detailed and accurate. A great reference for your own shelf, and also an ideal gift for a friend or family member who wants to understand what it is you do all day. . . .

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Bebop Bytes Back

By Clive "Max" Maxfield and Alvin Brown

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The Foreword by Lee Felsenstein reads:

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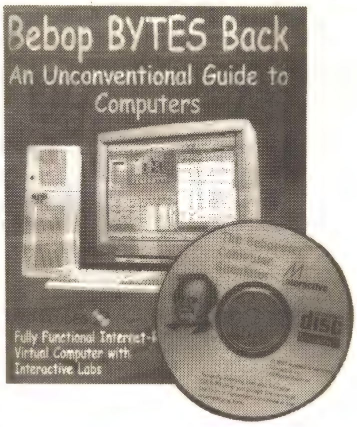
2. The labs work on two levels: on and under the surface. When you're performing the labs you'll need to look for patterns that build up from individual events.

3. When you're done, you won't look any different. You won't get a trophy or a certificate to hang on your wall. You'll have some knowledge, and some skill, and you'll be ready to find more knowledge and develop more skill. Much of this will be recognisable only to someone who has the same knowledge and skill."


Bebop BYTES Back
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This follow-on to *Bebop to the Boolean Boogie* is a multimedia extravaganza of information about how computers work. It picks up where "Bebop I" left off, guiding you through the fascinating world of computer design . . . and you'll have a few chuckles, if not belly laughs, along the way. In addition to over 200 megabytes of mega-cool multimedia, the accompanying CD-ROM (for Windows 95 machines only) contains a virtual microcomputer, simulating the motherboard and standard computer peripherals in an extremely realistic manner. In addition to a wealth of technical information, myriad nuggets of trivia, and hundreds of carefully drawn illustrations, the book contains a set of lab experiments for the virtual microcomputer that let you recreate the experiences of early computer pioneers.

If you're the slightest bit interested in the inner workings of computers, then don't dare to miss this one!

Audio and Music

VALVE & TRANSISTOR AUDIO AMPLIFIERS

John Linsley Hood

This is John Linsley Hood's greatest work yet, describing the milestones that have marked the development of audio amplifiers since the earliest days to the latest systems. Including classic amps with valves at their heart and exciting new designs using the latest components, this book is the complete world guide to audio amp design.

Contents: Active components; Valves or vacuum tubes; Solid-state devices; Passive components; Inductors and transformers; Capacitors, Resistors, Switches and electrical contacts; Voltage amplifier stages using valves; Valve audio amplifier layouts; Negative feedback; Valve operated power amplifiers; Solid state voltage amplifiers; Early solid-state audio amplifiers; Contemporary power amplifier designs; Preamplifiers; Power supplies (PSUs); Index.

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AUDIO AMPLIFIER PROJECTS

R. A. Penfold

A wide range of useful audio amplifier projects, each project features a circuit diagram, an explanation of the circuit operation and a stripboard layout diagram. All constructional details are provided along with a shopping list of components, and none of the designs requires the use of any test equipment in order to set up properly. All the projects are designed for straightforward assembly on simple circuit boards.

Circuits include: High impedance mic preamp, Low impedance mic preamp, Crystal mic preamp, Guitar and GP preamplifier, Scratch and rumble filter, RIAA preamplifier, Tape preamplifier, Audio limiter, Bass and treble tone controls, Loudness filter, Loudness control, Simple graphic equaliser, Basic audio mixer, Small (300mW) audio power amp, 6 watt audio power amp, 20/32 watt power amp and power supply, Dynamic noise limiter.

A must for audio enthusiasts with more sense than money!

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Ian Waugh

In this practical and clearly-written book, Ian Waugh explains all aspects of the subject from digital audio basics to putting together a system to suit your own music requirements. Using the minimum of technical language, the book explains exactly what you need to know about: Sound and digital audio, Basic digital recording principles, Sample rates and resolutions, Consumer sound cards and dedicated digital audio cards.

On a practical level you will learn about: sample editing, digital multi-tracking, digital FX processing, integrating MIDI and digital audio, using sample CDs, mastering to DAT and direct to CD, digital audio and Multimedia.

This book is for every musician who wants to be a part of the most important development in music since the invention of the gramophone. It's affordable, it's flexible, it's powerful and it's here now! It's digital and it's the future of music making.

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CIRCUITS AND DESIGN

AN INTRODUCTION TO PIC MICROCONTROLLERS
Robert Penfold

Designing your own PIC based projects may seem a daunting task, but it is really not too difficult providing you have some previous experience of electronics. The PIC processors have plenty of useful features, but they are still reasonably simple and straightforward to use. This book should contain everything you need to know.

Topics covered include: the PIC register set; numbering systems; bitwise operations and rotation; the PIC instruction set; using interrupts; using the analogue to digital converter; clock circuits; using the real time clock counter (RTCC); using subroutines; driving seven segment displays.

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PRACTICAL OSCILLATOR CIRCUITS
A. Flind

Extensive coverage is given to circuits using capacitors and resistors to control frequency. Designs using CMOS, timer i.c.s and op.amps are all described in detail, with a special chapter on "waveform generator" i.c.s. Reliable "white" and "pink" noise generator circuits are also included.

Various circuits using inductors and capacitors are covered, with emphasis on stable low frequency generation. Some of these are amazingly simple, but are still very useful signal sources.

Crystal oscillators have their own chapter. Many of the circuits shown are readily available special i.c.s for simplicity and reliability, and offer several output frequencies. Finally, complete constructional details are given for an audio sinewave generator.

133 pages **Order code BP393** **£4.99**

PRACTICAL ELECTRONIC CONTROL PROJECTS
Owen Bishop

Explains electronic control theory in simple, non-mathematical terms and is illustrated by 30 practical designs suitable for the student or hobbyist to build. Shows how to use sensors as input to the control system, and how to provide output to lamps, heaters, solenoids, relays and motors.

Computer based control is explained by practical examples that can be run on a PC. For stand-alone systems, the projects use microcontrollers, such as the inexpensive and easy-to-use Stamp BASIC microcontroller. These projects are chosen to introduce and demonstrate as many aspects as possible of the programming language and techniques.

198 pages **Order code BP377** **£5.99**

PRACTICAL ELECTRONICS HANDBOOK – Fourth Edition. Ian Sinclair

Contains all of the everyday information that anyone working in electronics will need.

It provides a practical and comprehensive collection of circuits, rules of thumb and design data for professional engineers, students and enthusaists, and therefore enough background to allow the understanding and development of a range of basic circuits.

Contents: Passive components, Active discrete components, Discrete component circuits, Sensing components, Linear I.C.s, Digital I.C.s, Microprocessors and microprocessor systems, Transferring digital data, Digital-analogue conversions, Computer aids in electronics, Hardware components and practical work, Standard metric wire table, Bibliography, The HEX scale, Index.

440 pages **Order code NE21** **£14.99**

COIL DESIGN AND CONSTRUCTIONAL MANUAL
B. B. Babani

A complete book for the home constructor on "how to make" RF, IF, audio and power coils, chokes and transformers. Practically every possible type is discussed and calculations necessary are given and explained in detail. Although this book is now twenty years old, with the exception of toroids and pulse transformers little has changed in coil design since it was written.

96 pages **Order code 160** **£3.99**

OPTOELECTRONICS CIRCUITS MANUAL
R. M. Marston

A useful single-volume guide to the optoelectronics device user, specifically aimed at the practical design engineer, technician, and the experimenter, as well as the electronics student and amateur. It deals with the subject in an easy-to-read, down-to-earth, and non-mathematical yet comprehensive manner, explaining the basic principles and characteristics of the best known devices, and presenting the reader with many practical applications and over 200 circuits. Most of the i.c.s and other devices used are inexpensive and readily available types, with universally recognised type numbers.

182 pages **Order code NE14** **£14.99**

OPERATIONAL AMPLIFIER USER'S HANDBOOK
R. A. Penfold

The first part of this book covers standard operational amplifier based "building blocks" (integrator, precision rectifier, function generator, amplifiers, etc), and considers the ways in which modern devices can be used to give superior performance in each one. The second part describes a number of practical circuits that exploit modern operational amplifiers, such as high slew-rate, ultra low noise, and low input offset devices. The projects include: Low noise tape preamplifier, low noise RIAA preamplifier, audio power amplifiers, d.c. power controllers, opto-isolator audio link, audio millivolt meter, temperature monitor, low distortion audio signal generator, simple video fader, and many more.

120 pages **Order code BP335** **£4.95**

A BEGINNERS GUIDE TO CMOS DIGITAL ICs
R. A. Penfold

Getting started with logic circuits can be difficult, since many of the fundamental concepts of digital design tend to seem rather abstract, and remote from obviously useful applications. This book covers the basic theory of digital electronics and the use of CMOS integrated circuits, but does not lose sight of the fact that digital electronics has numerous "real world" applications.

The topics covered in this book include: the basic concepts of logic circuits; the functions of gates, inverters and other logic "building blocks"; CMOS logic i.c. characteristics, and their advantages in practical circuit design; oscillators and monostables (timers); flip/flops, binary dividers and binary counters; decade counters and display drivers.

The emphasis is on a practical treatment of the subject, and all the circuits are based on "real" CMOS devices. A number of the circuits demonstrate the use of CMOS logic i.c.s in practical applications.

119 pages **Order code BP333** **£4.95**

AUDIO AND MUSIC

INTRODUCTION TO DIGITAL AUDIO
(Second Edition)
Ian Sinclair

Digital recording methods have existed for many years and have become familiar to the professional recording engineer, but the compact disc (CD) was the first device to bring audio methods into the home. The next step is the appearance of digital audio tape (DAT) equipment.

All this development has involved methods and circuits that are totally alien to the technician or keen amateur who has previously worked with audio circuits. The principles and practices of digital audio owe little or nothing to the traditional linear circuits of the past, and are much more comprehensible to today's computer engineer than the older generation of audio engineers.

This book is intended to bridge the gap of understanding for the technician and enthusiast. The principles and methods are explained, but the mathematical background and theory is avoided, other than to state the end product.

128 pages **Order code PC102** **£7.95**

PROJECTS FOR THE ELECTRIC GUITAR
J. Chatwin

This book is for anyone interested in the electric guitar. It explains how the electronic functions of the instrument work together, and includes information on the various pickups and transducers that can be fitted. There are complete circuit diagrams for the major types of instrument, as well as a selection of wiring modifications and pickup switching circuits. These can be used to help you create your own custom wiring.

Along with the electric guitar, sections are also included relating to acoustic instruments. The function of specialised piezoelectric pickups is explained and there are detailed instructions on how to make your own contact and bridge transducers. The projects range from simple preamps and tone boosters, to complete active controls and equaliser units.

92 pages **Order code BP358** **£4.95**

MIDI SURVIVAL GUIDE
Vic Lennard

Whether you're a beginner or a seasoned pro, the MIDI Survival Guide shows you the way. No maths, no MIDI theory, just practical advice on starting up, setting up and ending up with a working MIDI system.

Over 40 cabling diagrams. Connect synths, sound modules, sequencers, drum machines and multitracks. How to budget and buy secondhand. Using switch, thru and merger boxes. Transfer songs between different sequencers. Get the best out of General MIDI. Understand MIDI implementation charts. No MIDI theory.

104 pages **Temporarily out of print**

PRACTICAL ELECTRONIC MUSICAL EFFECTS UNITS
R. A. Penfold

This book provides practical circuits for a number of electronic musical effects units. All can be built at relatively low cost, and use standard, readily available components. The projects covered include: Waa-Waa Units; Distortion Units; Phaser; Guitar Envelope Shaper; Compressor; Tremolo Unit; Metal Effects Unit; Bass and Treble Boosters; Graphic Equaliser; Parametric Equaliser. The projects cover a range of complexities, but most are well within the capabilities of the average electronics hobbyist. None of them require the use of test equipment and several are suitable for near beginners.

102 pages **Order code BP368** **£4.95**

LOUDSPEAKERS FOR MUSICIANS
Vivan Capel

This book contains all that a working musician needs to know about loudspeakers; the different types, how they work, the most suitable for different instruments, for cabaret work, and for vocals. It gives tips on constructing cabinets, wiring up, when and where to use wadding, and when not to, what fittings are available, finishing, how to ensure they travel well, how to connect multi-speaker arrays and much more.

Ten practical enclosure designs with plans and comments are given in the last chapter, but by the time you've read that far you should be able to design your own!

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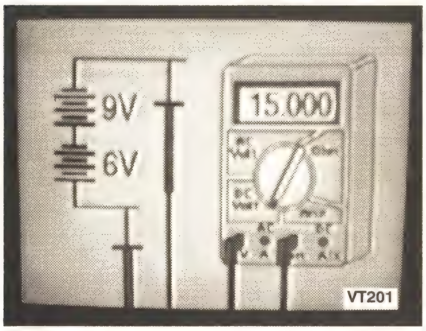

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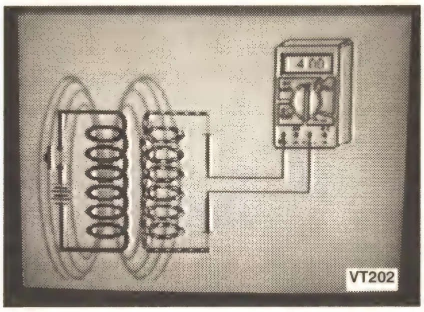

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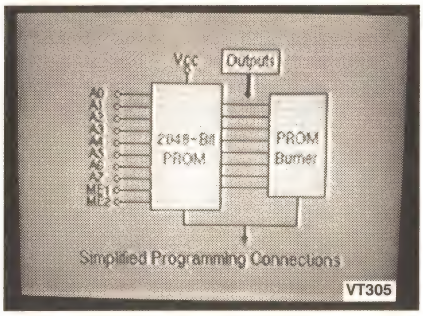

ach video uses a mixture of animated current flow in circuits plus text, plus cartoon instruction etc., and a very full commentary to get the points across. The tapes are imported by us and originate from VCR Educational Products Co, an American supplier. We are the worldwide distributors of the PAL and SECAM versions of these tapes. (All videos are to the UK PAL standard on VHS tapes unless you specifically request SECAM versions.)

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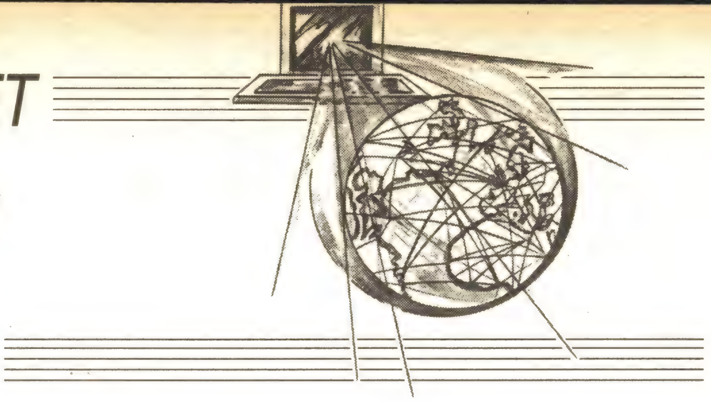
SURFING THE INTERNET

NET WORK

ALAN WINSTANLEY



HAPPY KRIZ-MAS

THE worm **Happy99.exe** is the most-reported virus in Europe, according to virus detection specialists Symantec (**www.symantec.com/avcenter**) – discussions of worms, Trojan Horses and viruses (or viri/virii!) took place in earlier editions of *Net Work*.

A new Windows virus called **W32.Kriz.3863** (and variants) is starting to appear, Symantec says, and this particularly nasty virus can damage critical Windows system files. Furthermore, on December 25th it will deliver a payload by flashing the BIOS of the host computer. Damage to a PC's BIOS (Basic Input/Output Operating System) chip is disastrous, because this PROM chip contains all the system configuration which is interrogated when the PC starts up.

A faulty BIOS can cripple a PC system completely: I discovered this for myself when I installed a Philips 646 USB webcam, and found that my PC would no longer boot up when the camera was plugged in. Considering that USB is a hot-swappable technology, I was not impressed. However it became apparent that the BIOS required flashing to update the USB handling, and after a quick visit to the Dell web site, all was well.

Symantec have once again posted information on the latest viruses on their own web site, and as if Y2K worries aren't enough, this Chernobyl-like virus is one to guard against if your Christmas on the Net is to be a happy one.

I-SEEK-YOU

At nearly 750,000 hits per week, ICQ (I-Seek-You) must rate as one of the world's most popular programs (followed by WinZip) if the stats at *download.com* are to be believed. ICQ is a very useful and customisable "chat" and messaging program which has a number of cute tricks up its sleeve. It is a neat and thoroughly sorted program, and best of all – it's free!

An ICQ user is allocated a unique digital ID number (this is the "ICQ #23501235" that you often see in a user's signature) and users can then compile a list of other ICQ users with whom they wish to communicate.

When ICQ is started up (e.g. by dialling into the Internet), this logs the user into the ICQ network, a process which can happen instantaneously when the system isn't busy. After successfully logging in, the network updates your ICQ list to show you who else on your list is also on-line at that time. Similarly those users are also alerted by ICQ that you have gone on-line.

At this point several options become available. You can simply fire off a quick message to any user on your list. If they are logged on they may receive it within a few seconds, and you might get a reply say a minute or so after that; however if they are not currently connected to ICQ, then the message can be delivered when they next log on.

It is also possible to forward any web URLs which you think may be of interest to other users, which is a good way of sharing web resources. There are also plenty of web sites which are specially provided to enable a sentiment (e.g. a poem or humour) to be mailed to other users. ICQ lets you easily transfer files (e.g. word-processing documents or other files) to other users on your list when they are on line. An E-mail service is also provided by ICQ, and you can send voice greetings when on-line too. Handy "To Do" lists and Windows desktop reminder notes are built in for the benefit of those who run ICQ at their desks, and almost everything you see is customisable. A reasonable ICQ search engine facilitates convenient web searches.

There's more fun still with the ICQ Chat facility; seasoned users will probably have used IRC (Internet Relay Chat) but ICQ Chat adds many amusing features. Messages can be typed in by one user which appear in real time in the corresponding user's window. They reply the same way, and a conversation can carry on all night! There are several Chat enhancements included: sound effects can be played on the other user's computer, such as an attention-grabbing klaxon. Sounds (e.g. giggling or coughing effects) can be associated with typed messages too. Chat sessions can also be stored and played back later, and like watching those pianos that play themselves, seeing the chat unfold is quite an eerie feeling!

The versatility of ICQ doesn't end there, however. I have sometimes envied a number of my American ICQ friends who leave their ICQ connection live all day (or night). Remember that American users can enjoy a full-time dialled-in connection by paying a standard flat rate per month. If they decide to go out, they can still leave their system hooked up to the ICQ network, and they can notify that they are away by changing their on-line ICQ status - such as "Extended Away" or "Not Available." If they actually need to do some work, they can leave ICQ running and display a "Do Not Disturb" or "Occupied" message.

ICQ IN PRIVATE

A number of privacy features are available. You can make yourself "invisible" to certain other users so that they are unaware of your presence on ICQ. You therefore call the shots and can then decide whether or not to contact them. To prevent your ICQ number from finding its way onto the lists of countless other users, you can set an option whereby permission must be sought first: seldom will I give mine, before you ask! Hence your individual ICQ list develops into a selected list of friends and contacts and there is no worry about being pestered by other users (unless you choose a "random chat" session with a complete stranger).

The use of ICQ for conversing with others has its share of dangers though. There is the ever-present risk that a careless choice of words could be misinterpreted by the recipient, so if you wish to avoid any upsets or disappointments due care should be exercised, especially with real-time ICQ Chat. Make liberal use of emoticons (smileys) at appropriate times just to be sure. Also, there can be delivery delays with ICQ messages sent to off-line users, so this system should not necessarily be relied upon for important communications.

It is best to tailor ICQ to fit your own work pattern, and don't feel guilty if you simply cannot spare the time to engage in a discussion at that moment. Everyone else on your list gets busy too, and a pattern of sending quick ICQ messages usually emerges. Don't burden yourself with a burgeoning list of users either: some occasional housekeeping is useful in keeping the list down to manageable levels. Life on ICQ can be rapid-fire and brief, or it can take up an entire evening if desired. It's a sure way of making new friends, or staying in touch with existing ones, and some users just can't live without it.

How to install ICQ: it is easiest to visit **www.download.com** and search for the file. There have been rumours of virus-infected versions being distributed from unofficial sites, so be sure to fetch only from trusted sources. You should also visit **www.icq.com**.

LINKS

Ever since *Net Work* started over three years ago, I have provided links for readers to check when surfing the Net. In practice, because so many web sites are now available it is proving difficult to provide a constantly updated link resource in the form of the *Net Work A-Z Index*. Some links go down as quickly as they appear, especially amongst hobbyist pages: users are sometimes keen to announce new sites but less eager to say when they are deleted. I feel that I have gathered sufficient links together to provide a reasonable resource which I am trying to refine further. Readers' feedback is welcomed by E-mail to **alan@epemag.demon.co.uk**.

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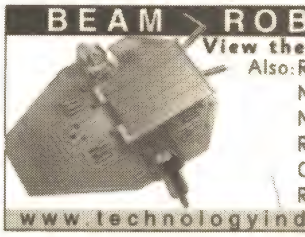

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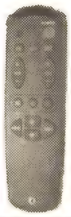

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Access the FTP site by typing the above into your web browser, or by setting up an FTP session using appropriate FTP software, then go into quoted sub-directories:

PIC-project source code files: **/pub/PICS**

PIC projects each have their own folder; navigate to the correct folder and open it, then fetch all the files contained within. *Do not try to download the folder itself!*

EPE text files: **/pub/docs**

Basic Soldering Guide: **solder.txt**

EPE TENS Unit user advice: **tens.doc** and **tens.txt**

Ingenuity Unlimited submission guidance: **ing_unlt.txt**

New readers and subscribers info: **epe_info.txt**

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Ni-Cad discussion: **nicadfaq.zip** and **nicad2.zip**

UK Sources FAQ: **uksource.zip**

Writing for *EPE* advice: **write4us.txt**

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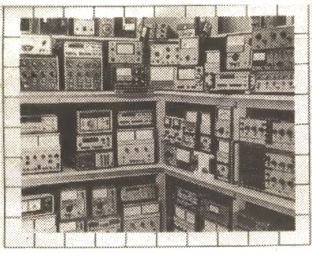

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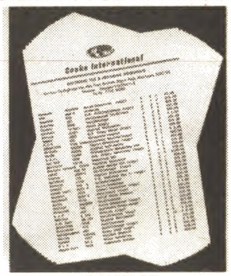

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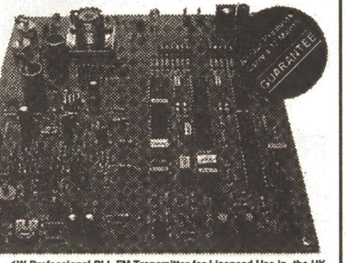

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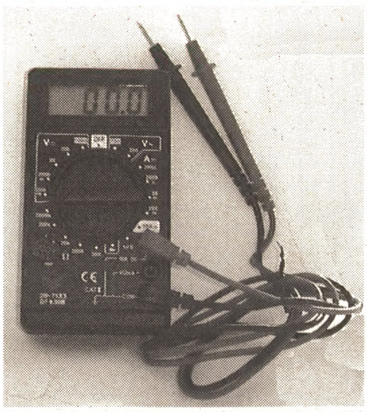

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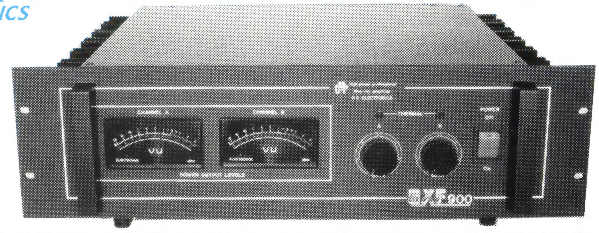

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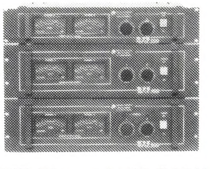

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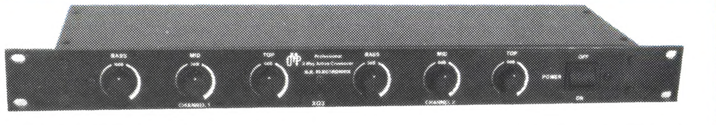

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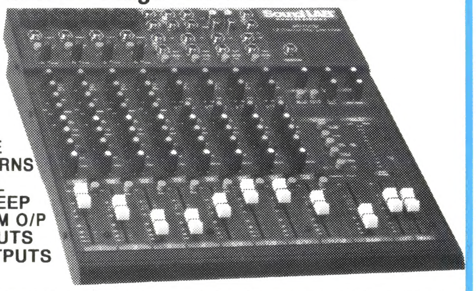

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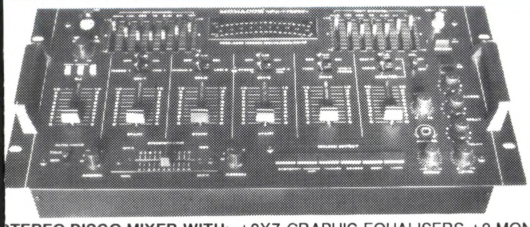

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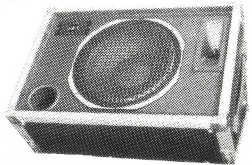

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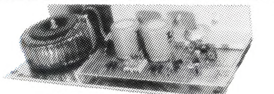

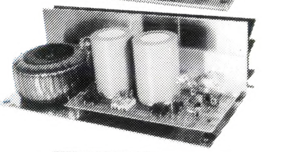

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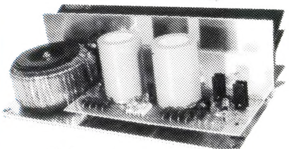
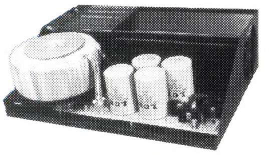


OMP/MF 300 Mos-Fet Output power 300 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 60V/uS, T.H.D. typical 0.001%, Input Sensitivity 500mV, S.N.R. -110dB. Size 330 x 175 x 100mm.
PRICE:- £83.75 + £5.00 P&P

OMP/MF 450 Mos-Fet Output power 450 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 75V/uS, T.H.D. typical 0.001%, Input Sensitivity 500mV, S.N.R. -110dB, Fan Cooled, D.C. Loudspeaker Protection, 2 Second Anti-Thump Delay. Size 385 x 210 x 105mm.
PRICE:- £135.85 +£6.00 P&P



OMP/MF 1000 Mos-Fet Output power 1000 watts R.M.S. into 2 ohms, 725 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 75V/uS, T.H.D. typical 0.002%, Input Sensitivity 500mV, S.N.R. -110dB, Fan Cooled, D.C. Loudspeaker Protection, 2 Second Anti-Thump Delay. Size 422 x 300 x 125mm.
PRICE:- £261.00 + £12.00 P&P

NOTE: MOS-FET MODULES ARE AVAILABLE IN TWO VERSIONS: STANDARD - INPUT SENS 500mV, BAND WIDTH 100KHz. OR PEC (PROFESSIONAL EQUIPMENT COMPATIBLE) - INPUT SENS 775mV, BAND WIDTH 50KHz. **ORDER STANDARD OR PEC**

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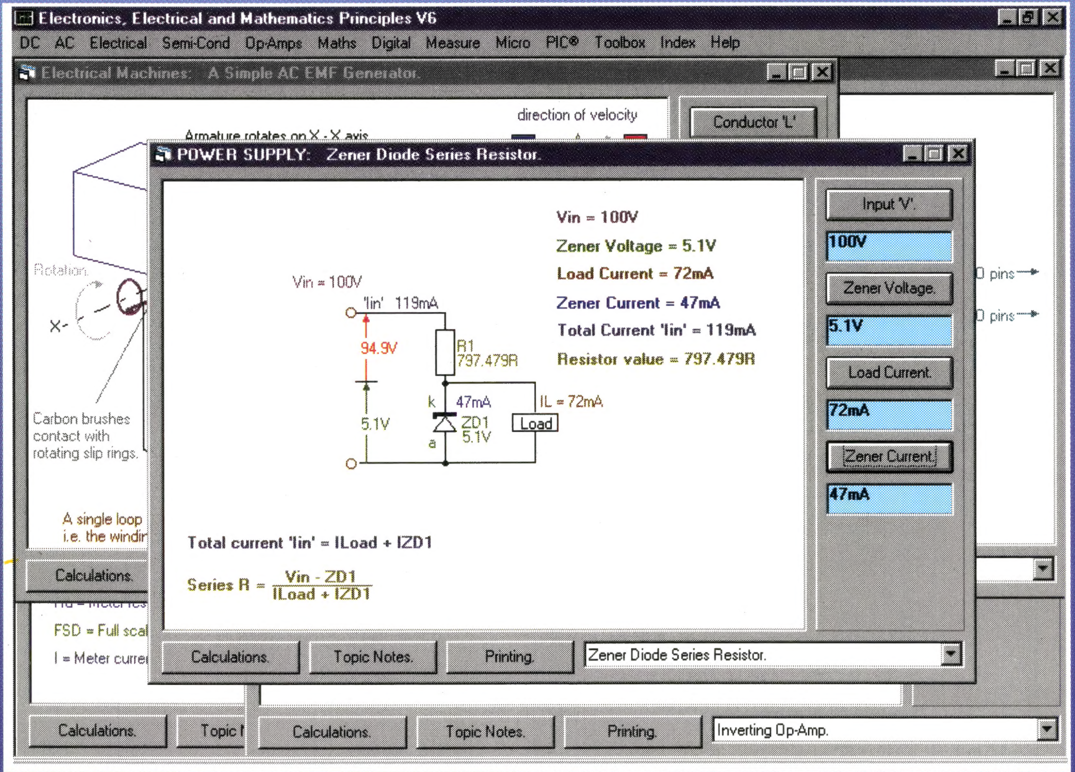
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Conductor 'L'
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X-
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